Calculations in Yarns and Fabrics.

By

Fred Bradbury.

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Calculations

IN

Yarns and Fabrics.

(Eighth Thousand.)

BY

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FLAX CULTURE AND PREPARATION, ETC., ETC.

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PREFACE TO THE THIRD EDITION

In issuing a revised and enlarged edition of "Calculations in Yarns and Fabrics," I avail myself of the opportunity to thank all those who have written expressing their appreciation of the former editions, particularly in reference to the worked examples together with the exercises and answers for same at the end of each chapter and also to the extensive chapter on "Analysis and Reproduction of Woven Fabrics."

In this edition four new chapters have been added and much new matter to almost every other chapter.

It is important to note that, in Chapters VI and XI which deal with the costing of yarns and the weight and cost of woven fabrics respectively, the prices used in conjunction with the demonstration of the fundamental principles of costing have been taken at exactly twice the pre-war rate though prices do not in any way affect the principle and method of solution. After much thought on this problematic

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subject I concluded that when prices are eventually stabilised they will approximate to twice the pre-war amount, due chiefly to increased wages, reduced working hours, increased cost of raw material, increased freightage and increased initial and capital expenses, none of which is likely to recede to its pre-war figure.

The issue of this edition has been unavoidably delayed owing to the war but I trust that the extra time and care which have been allotted to its preparation will compensate, to some extent, for the delay in its publication.

My sincerest wish is that, like its predecessors, it will be found helpful to the Student, Teacher, Spinner, Manufacturer and Merchant alike.

F. B.

BELFAST.

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21	34	14,400	144,000
26	Table I.	2,000	2,200
104	6	440	400

CALCULATIONS

IN

YARNS AND FABRICS.

CHAPTER I.

Various Systems of Counting Yarns.

To explain in detail all the several systems of numbering or counting yarns is well nigh impossible since their variety is truly legion. Briefly, the terms 'count,' 'lea,' 'run,' 'skeins,' 'cuts,' 'spindle,' etc., literally represent a certain length of yarn for a fixed weight or *vice versa*, but unfortunately, a uniform standard has not yet been adopted. Of the advantage to be gained by the adoption of such a standard there can be but little doubt. The universal system or method which should and will eventually become general remains a problem of the future.

Comparatively it is easier to formulate a more uniform method of numbering yarns than it is to establish one, for the difficulties of the problem increase with the study of the subject. The various systems being the growth of ages have woven around

them many factors of established interests and customs *e.g.*, reels and yarn testing apparatus are made to standard sizes and adapted to suit the different denominations. Manufacturers and employees have, after much deliberation, fixed prices to be paid for weaving yarns of specified numbers combined with other factors.

Any radical change from the present system of counting yarns would involve a reconsideration by employers and their departmental managers with the employees and their leaders through each respective country, with a probable dislocation of trade.

Any change which may eventually take place will and can only come gradually, *i.e.* by a process of evolution. The first probable and desirable result of such evolution will be *one system* for each respective fibre:—silk, wool, flax, cotton and jute, etc.

Worsted Yarns.

English Counts.

In all English speaking countries worsted yarn is calculated as follows:—

Circumference of reel = 36 ins. = 1 Thread.
80 Threads or revs. of reel = 80yds. = Rap or Lea
7 Raps or Leas = 560yds. = 1 Hank.

The number of such hanks of 560 yards which weighs 1 lb. avoirdupois is designated the counts.

The term 'hank' is but a figure, for the material may either be in the form of weft on spools and bobbins or warp in the ball or on the warp-beam, and not necessarily made into hanks of 560 yards length. Therefore, if the length of a given weight be known it

will be obvious that whether the yarn be made into hanks or in any other form it can readily be reduced to the form of 'counts' or lengths of 560 yards which weigh 1 lb.

Continental Counts.

This method is based upon the number of unit lengths of 1000 metres each, which weighs 1 kilogramme. *e.g.*,

10's counts = 10 × 1000 metres = 10,000 metres per kilo.
16's „ = 16 × 1000 „ = 16,000 „
1 metre = 1·094 yards.
1 kilogramme = 2·205 lbs. = 15·432 grains.

N.B.—For the metric system of weights and measures, see page 27

Owing to the inconvenience of readily converting Continental into English counts and *vice versa*, by having to compare metres with yards and kilogrammes with lbs., the following formulæ are deduced, which will be found of much practical advantage.

Example 1.—Find the decimal formula for converting Continental worsted counts into English worsted counts and *vice versa*.

1s French or Continental worsted counts

$$= \frac{1094 \text{ yds. per 1000 metres}}{2{\cdot}205 \text{ lbs. per kilogramme}} = 496 \text{ yards per lb.,}$$

and basis of English counts = 560 yards per lb. for 1s counts.

$$\therefore \frac{496}{560} = 0{\cdot}885 \text{ (nearest third decimal place).}$$

Obviously then the English unit count is finer than that of the Continental, since 560 yards of the former weigh 1 lb. to each 496 yards of the latter.

∴ 0·885 English = 1s Continental counts.

Numerically the English worsted equivalent will always be less than its Continental contemporary thus:—

Then 0·885s English is equal to 1s Continental counts, or 0·885 times Continental counts equals English counts, and English counts divided by 0·885 equals Continental counts.

FORMULA A.

(a) English counts ÷ 0·885 = Continental worsted.
(b) Continental worsted × 0·885 = English counts.

NOTE.—0·9 is a convenient number for mental calculation on the Exchange, and sufficiently accurate for practical work.

Example 2.—36s English equals

36 ÷ 0·9 = 40s Continental approximately,
or 36 ÷ ·885 = 40·7s Continental actually.

As an *alternative* plan to the foregoing, the following method may be adopted which in some instances will be found simpler than by using 0·885 either as a multiplier or a divisor.

$$\frac{560 \text{ yards English hank}}{496 \text{ yards Continental hank}} = \frac{1{\cdot}13}{1}$$

FORMULA B.

(a) English counts × 1·13 = Continental.
(b) Continental counts ÷ 1·13 = English.

Example 3.—Convert 36s English worsted by Formula B into Continental counts.

Then 36 English × 1·13 = 40·68 Continental.

Woollen Yarns.

There are several systems of counting woollen yarns, notably the following:—

Galashiels is based upon the 'cut' of 300 yards in 24 ounces, *i.e.*, the number of cuts of 300 yards which weighs 24 ounces represents the counts, technically and locally termed 'cut.'

NOTE.—300 yards per 24 ozs. is equivalent to 200 yards per 16 ozs. (1 lb.) which number, being more convenient, is frequently adopted in practice, especially when changing from one count to any other.

Hawick is based upon the cut of 300 yards in 26 ounces.

West of England. consists of the hank of 320 yards, and the number of such hanks which weighs 1 lb. equals the counts; this is equivalent to 20 yards per oz., or the number of lengths of yarn of 20 yards each which weighs 1 oz. designates the counts.

Yorkshire Skein. This system at first appears somewhat complicated but when modified is really similar in principle to the foregoing. It is based upon the number of skeins of 1,536 yards each, in one 'warten' (6 lb.), or when reduced, for convenience, it represents 256 yards per skein per lb. for 1s count, and this is the basis reckoned in calculations considered in this treatise. By a further reduction of the above terms it will be noted that the number of yards which weighs 1 dram also equals the count, since 256 drams make 1 lb.

Halifax Rural District. In this system the counts are represented by the number of drams which 80 yards weigh, and this method it should be noted is diametric in principle to each of the foregoing systems.

American 'Cut.' The 'cut' system is based upon the number of 'cuts' of 300 yards each against a standard weight of 1 lb. avoirdupois, which is virtually the same as for linen.

American 'Run.' The 'Run' is based upon 100 yards as the unit length, and 1 oz. as the standard weight. The number of 'Runs' of 100 yards each which weighs 1 oz. is denominated the 'Run' or count, *e.g.*, 20s Run = 2,000 yards per oz.

American 'Grain System.' This system is diametrically opposed in principle to the two foregoing methods. It is based upon the weight *in grains* of 50 yards, *e.g.*, if 50 yards of yarn weigh 12, 15 or 18 grains, it is denominated 12s, 15s, or 18s grain yarn.

German Woollen Count Is based upon the hank of 2200 Berlin ells and the number of such hanks which weighs $\frac{1}{2}$ kilogramme or 500 grammes = the counts.

1 Berlin ell = $\frac{2}{3}$ metre.

Cotton Yarns.

English Counts. In all English speaking countries the basis of numbering cotton is on the hank of 840 yards prepared on a 54 inch reel as follows :—

1 Revolution of reel	54 ins. = $1\frac{1}{2}$ yds.	= 1 thread
80 Threads or revs. of reel	,, = 120 ,,	= 1 rap or lea
7 Raps or Leas	= 840 ,,	= 1 hank

and the number of such hanks which weighs 1 lb. denotes the counts.

Cotton yarns if made into bundles are "grossed" to weigh 5 or 10 lbs. each.

Continental Counts. The system of numbering cotton yarns on the Continent is based upon the number of unit lengths of 1000 metres each which weighs ½ kilogramme, *e.g.*,

10s continental cotton = 10 × 1000 metres = 10,000 metres per ½ kilogramme
20s " " = 20 × 1000 " = 20,000 " "

Example 4.—Find the decimal formula for converting Continental *cotton* counts into English cotton counts and *vice versa*.

1s French or Continental cotton counts

$$= \frac{1094 \text{ yards per 1000 metres}}{1{\cdot}1025 \text{ lbs. per } \frac{1}{2} \text{ kilogramme}} = 992 \text{ yds. per lb.,}$$

and basis of English counts = 840 yards per lb. for 1s counts.

$$\therefore \frac{992}{840} = 1{\cdot}18.$$

Then 1s Continental = 1·18s English cotton, or, 1·18 times Continental counts equals English counts, and English counts divided by 1·18 equals Continental counts.

FORMULA C.

(a) English counts ÷ 1·18 = Continental counts.
(b) Continental counts × 1·18 = English counts.

Flax Yarns.

Flax is a vegetable fibre, the botanical name of which is *Linum usitatissimum;* it is prepared and spun into two chief classes of linen yarn; (1) Long or line yarn. (2) Short or tow yarn.

Line Yarn is prepared by hackling, gill preparing, drawing, roving and spinning.

The process of spinning is generally performed 'wet,' *i.e.* the roving, during this operation and before it enters the nip of the back rollers, passes through a trough filled with hot water, the object being to soften the natural gummy substances attached to the flax fibres and thereby reduce them to their ultimate length and fineness. The 'unit' length of the degummed and detached fibre is about 1½ to 2 inches.

Numbering. The principle of numbering 'line' yarns may be sub-divided into five sections.

A. The Irish Linen Yarn Table.

Circumference of reel	= 90 ins.	= 2½ yds	= 1 thread
120 thds. or revs. of reel	= (120 × 2½) yds.	= 300 yds	= 1 cut or lea
12 cuts or leas	= 12 × 300 yds.	= 3,600 yds.	= 1 hank
16⅔ hanks or 200 cuts	= 60,000 yds.	= 1 Bundle	
3 Bundles	= 180,000 yds.	= 1 Belgian Pacquet	
6 Bundles	= 360,000 yds.	= 1 French Pacquet.	

The number of cuts or leas of 300 yards each which weighs 1 lb. avoirdupois, is denominated the *counts* or *lea number*.

Linen yarn is bought and sold by the bundle. It is usually made into 'bunches' for convenience of storage or transit. From 1½ to 12 bundles are sometimes grouped together, though 3, 6 or 12 are most generally selected to form a bunch. The following may be accepted as types.

Up to 20s lea	...	1½ bundles per bunch.
20 to 30 ...	...	3 ,, ,, ,,
30 to 70 ...	...	6 ,, ,, ,,
70 to 100 ...	...	9 ,, ,, ,,
100 and upwards	...	12 ,, ,, ,,

N.B.—The number of bundles per bunch, for any given lea, varies according to the ideas of the spinner.

The Irish method of numbering yarns is now generally adopted throughout English speaking countries. Also the large quantities of flax yarns exported, during recent years, from France and Belgium into the British Islands have been prepared and spun to Irish numbers.

B. English (Yorks.) Linen Yarn Table.

Circumference of reel	= 108ins. =	3 yards = 1 Thread.
100 Threads or revs. of reel	= 100 × 3 =	300 ,, = 1 Cut or Lea.
10 Cuts or Leas	= 10 × 300 =	3,000 ,, = 1 Hank.
20 Hanks or 200 Cuts		= 60,000 ,, = 1 Bundle.

C. Short Reeled Linen Yarn Table.

Circumference of reel	= 54ins.	= 1½ yards	= 1 Thread
100 Threads or revs. of reel	= 100 × 1½ yds. =	150 ,,	= 1 Cut or Lea
10 Cuts or Leas	= 10 × 150 ,, =	1,500 ,,	= 1 Eng. hank*
12 ,, ,,	= 12 × 150 ,, =	1,800 ,,	= 1 Irish hank*
40 English Hanks	= 40 × 1500 ,,	= 60,000 ,,	= 1 Bundle
33⅓ Irish Hanks	= 33⅓ × 1800 ,,	= 60,000 ,,	= 1 Bundle

*Denominated, short reeled

D. French Flax Counts.

Circumference of reel = 2½ yards = 2·285 m. = 1 tour.

Paquet.	Dévidoir.	Écheveau.	Échevette.	Tour.	Yards.	Metres.
				1 =	2½ =	2·28
			1 =	120 =	300 =	277·2
		1 =	12 =	1,440 =	3,600 =	3290·4
	1 =	25 =	300 =	36,000 =	90,000 =	82,260
1 =	4 =	100 =	1,200 =	144,000 =	360,000 =	329,040

E. French Flax Counts—Short Reeled for very fine yarns.

Circumference of reel = 54ins. = 1½ yds. = 1 tour. = 1 m., 371 m/m.

Paquet.	Deroidoir.	Écheveau	Échevette.	Tour.	Yards.	Metres.
				1 =	1½ =	1.371
			1 =	100 =	150 =	137·1
		1 =	10 =	1,000 =	1,500 =	1371
	1 =	24 =	240 =	24,000 =	36,000 =	32,904
1 =	10 =	240 =	2,400 =	240,000 =	360,000 =	329,040

Tow Yarn.

This is prepared from the short fibres which have been combed out of the flax material during the preparatory processes of roughing and hackling. The flax tow fibre bears the same relation to line sliver that '*noil*' does to combed top in worsted.

The flax tow fibres are used as self qualities, or blended according to the quality required, then carded prior to passing through a set of preparing and spinning machinery. The spinning process is performed wet, dry or by a damping process according to the fineness, condition or character of yarn required. The counts of dry spun yarn seldom exceed 16s lea.

The basis of numbering is generally the same as for fine linen. In some few cases where very coarse yarns are spun the same method of reckoning is adopted as for *Jute*.

F. Jute and Heavy Flaxes Yarn Table.

Circumference of reel	=	9oins.	= 2½ yards = 1 thread.
120 Thds. or revs. of reel	=	120 × 2½ yds. =	300 ,, = 1 cut or lea.
2 Cuts or Leas	=	2 × 300 ,, =	600 ,, = 1 heer.
6 Heers	=	6 × 600 ,, =	3,600 ,, = 1 hank.
4 Hanks or 48 Cuts	=	4 × 3,600 ,, =	14,400 ,, = 1 spindle or spangle.

The numbering of jute and heavy flaxes is based upon the weight in lbs. per spindle of 14,400 yards, *e.g.* If 14,400 yards weigh 8, 10 or 12 lbs. the grist of the yarn is called 8, 10 or 12 lb. respectively.

Hemp is reckoned on the same basis as flax and jute according to whether the yarn is very fine or coarse.

Flax, line and tow, jute and hemp yarns are frequently subjected to bleaching and dyeing processess, but the number of the yarn represents its count when it leaves the spinning and reeling room and contains the standard allowance of moisture.—See conditioning.

Silk Yarns.

The Denier System. This system is used throughout the world for *raw* or *net* Silk. Some manufacturers who throw their own raw silk for weaving, retain the Denier system throughout for the sake of unity.

The Denier system is based upon the hank of 400 French ells equivalent to 476 metres or 520 yds., and the weight of this hank in deniers represents the counts.

The circumference of the hand reel on which silk from the cocoons was *formerly* wound, was one French ell. A full silk skein, consisting of 400 revolutions, was removed and weighed against the denier.

1 denier $= \frac{1}{533\frac{1}{3}}$ ozs. = 0·05315 grammes.

1 gramme = 15.432 grains and $437\frac{1}{2}$ grains = 1 oz.

Then if 1 hank weighs 20 to 30 deniers, the counts would be 20s or 30s denier respectively.

Raw Silk is reeled or thrown into one of the three following forms :—

Singles, Organzine and Tram.

The silk worm during its operation of spinning, emits *two* threads The two filaments adhere by means of a natural gum and appear as a *unit* thread.

The threads secreted in the cocoon by the silk worm are so fine that they cannot be used as individual threads ; they are therefore first prepared into 'singles' as it is termed by reeling several filaments together to form the finest unit thread which it is possible to use in the subsequent manufacture.

The cocoons of various species are naturally different in fineness of filament, and even those from the same race will sometimes vary.

The filament from six canton cocoons will mostly reel from 14 to 16 deniers ; Tussah silk, which is coarser, will reel to about 34 deniers from eight cocoons ; other qualities yield different results.

'Organzine' is the product of two or more singles which are *hard twisted*, or thrown as it is called, before and during the process of folding so as to make a strong thread which will serve for warp purposes.

'Tram' which is generally used for weft is made by *loosely* twisting together two or more singles.

Silk Throwsters generally reel organzine silk into skeins of 20,000 yards and tram silk into skeins of 10,000 yards each, though this latter is frequently reeled into skeins containing from 2,000 to 5,000 yards only. Singles are usually made into skeins of from 5,000 to 10,000 yards.

Yards per oz. *e.g.* 20,000 or 30,000 organzine silk, means 20,000 or 30,000 yards per oz. respectively.

The Dram System. Tram silk is frequently designated by this system, which is based upon the weight of 1,000 yards, in drams; *e.g.* if one such hank of 1,000 yards weighs 2, 3 or 4 drams, the counts would be 2s, 3s, or 4s dram yarn respectively.

Legal Silk Count. The legal silk count which was approved in Paris in 1900, is the basis employed for numbering *artificial* silk as well as for raw or thrown silk. The system is based on the skein of 450 metres and its weight in *half* decigrammes, thus:—If one skein of 450 metres in length weighs 100 half decigrammes, its legal silk number is designated 100s.

Spun Silk. Spun silk is remanufactured from damaged cocoons of raw silk and waste made by the silk "throwsters." The process of operations includes:—boiling, carding, combing, gilling, drawing, spinning, doubling and gassing. Though the spun thread retains some of the characteristics of the raw silk, it nevertheless suffers in lustre, strength and elasticity.

Spun silk is generally doubled and used as warp, with tram silk weft for the cheaper classes of fabrics, also as extra warp in the decoration of some cheaper fabric. It is seldom used as weft except for the zephyr make of fabric.

The system adopted for *numbering spun silk* is based, like cotton, on the hank of 840 yards, and the number of such hanks which weighs 1 lb. represents the counts, whether they be single, two, or more fold thread, the counts or hanks per lb. being written thus :—30/1 ; 30/2 ; 30/3 fold spun silk ; in each case there are 30 hanks per lb. irrespective of the number of strands which compose each yarn.

Thrown Silk numbered as Cotton.

Some manufacturers require the net silk to be prepared into hanks of 840 yards each, and like cotton, designated by the number of such hanks per lb. for counts.

YARN TABLE I.

LENGTH VARIABLE. WEIGHT CONSTANT.

System.	Unit of Length.	Unit of Weight.	Mode of Reckoning.
1. Worsted. (English) ..	560 yards	1 lb.	The number of units of length which weighs one unit weight = The Counts.
2. ,, (Continental)..	1000 metres	1 Kilogr	
3. Woollen. (Galashiels) ..	300 yards	24 ozs.	
4. ,, (Hawick) ..	300 ,,	26 ozs.	
5. ,, (West of Eng.)	320 ,,	1 lb.	
6 ,, (Yorks. Skein)	256 ,,	1 lb.	
7. ,, (Cut U.S.A.)..	300 ,,	1 lb.	
8. ,, (Run ,,)..	100 ,,	1 oz.	
9. ,, (German) ..	2200 Berlin ells	½ Kilogr	
10. Cotton. (English) ..	840 yards	1 lb.	
11. ,, (Continental) ..	1000 metres	½ Kilogr	
12. Linen. (Irish)	300 yards	1 lb.	
13. Silk. Spun	840 ,,	1 lb.	
14. Stirling and Alloa ..	14,400 ,,	24 lbs.	

N.B —Yorkshire Skein System may be considered as 256 yards per lb.
Galashiels ,, ,, ,, ,, ,, 200 ,, ,,
These modifications are adopted throughout this work.

YARN TABLE II.

LENGTH CONSTANT. WEIGHT VARIABLE.

System.	Unit of Length.	Unit of Weight.	Mode of Reckoning
Halifax Rural District ..	80 yards	drams ..	Weight in No. of drams of unit length = Counts.
Jute, Heavy Flaxes and Hemp	cuts yards 48 × 300 (spindle)..	lbs. ..	Weight in No. of lbs. Do.
Denier System	Raw {476 metres or Silks {520 yards	deniers	Weight in No. of deniers Do.
Dram System	1000 yards ..	drams ..	Weight in No. of drams Do.
Legal Silk Count Appd. Paris 1900	450 metres.. ..	½ Decigramme	Weight in No. of ½-decigrammes = Counts.
Grain .. .. (American)	50 yards	grains ..	Weight in No. of grains = Counts.

Metric System of Weights and Measures.

I.—TABLE OF LENGTH.

The unit of length is the metre = 39·37 inches.

		Metre.	Inch.	Yard.
1 Millimetre (mm.)		= $\frac{1}{1000}$	= ·03937	
10 Millimetres	= 1 Centimetre	= $\frac{1}{100}$	= ·3937	
10 Centimetres (cm.)	= 1 Decimetre	= $\frac{1}{10}$	= 3·937	
10 Decimetres (dcm.)	= 1 Metre	= 1	= 39·37	= 1·094
10 Metres (m.)	= 1 Decametre	= 10	= 393·7	= 10·94
10 Decametres (dkm.)	= 1 Hectometre	= 100	= 3937	= 109·4
10 Hectometres (hkm.)	= 1 Kilometre	= 1000	= 39370	= 1094.

II.—TABLE OF WEIGHTS.

The unit of weight is the gramme = 15·432 grains.

1 Milligramme	=		= $\frac{1}{1000}$ gme.	= ·015432 grains
10 Millimetres	= 1	Centigramme	= $\frac{1}{100}$,,	= ·15432 ,,
10 Centigrammes	= 1	Decigramme	= $\frac{1}{10}$,,	= 1·5432 ,,
10 Decigrammes	= 1	Gramme	= 1 ,,	= 15·432 ,,
10 Grammes	= 1	Decagramme	= 10 gms.	= 154·32 ,,
10 Decagrammes	= 1	Hectogramme	= 100 ,,	= 1543·2 ,,
10 Hectogrammes	= 1	Kilogramme	= 1000 ,,	= 15432 ,,

III.—MONETARY TABLE.

Monetary Unit	English equivalents.
1 Franc of 100 centimes	= 9·513d. or 25·22 Francs per £.

Examples on Length and Weight.

It will now be readily perceived that whenever a definite length of yarn is given together with its weight (or sufficient data to find these two essential factors), the *counts* of yarn in any one of the foregoing denominations can easily be determined.

Example 1.—Suppose 26,880 yards of yarn weigh 3 lbs., what is the 'count' of yarn in (*a*) worsted; (*b*) cotton; (*c*) linen; (*d*) Yorks. skeins, and (*e*) Gala. woollens?

(*a*) Then $\frac{26880}{3} = 8960$ yards per lb.

and $\frac{8960 \text{ yards per lb.}}{560 \text{ yards per hank}} = 16$ hanks per lb.

∴ 16s counts worsted, since the number of hanks which weighs 1 lb. equals the counts.

The whole may be simplified thus:—

FORMULA I.

Total length in yards = total weight in lbs. × yards per lb.

$\therefore$ $\frac{\text{Total length in yards}}{\text{Weight in lbs.} \times \text{yards per hank.}}$ = hanks per lb. = COUNTS.

(*a*) Worsted $= \frac{26880}{3 \times 560} =$ 16 hanks per lb. or 16s COUNTS.

(*b*) Cotton $= \frac{26880}{3} \times \frac{1}{840} =$ $10\frac{2}{3}$ COUNTS.

(*c*) Linen $= \frac{268 \cdot 0}{3} \times \frac{1}{300} =$ $29\frac{13}{15}$ LEA.

(*d*) Y. S. Woollen $= \frac{26880}{3} \times \frac{1}{256} =$ 35 Y. S.

(*e*) Gala. Woollen $= \frac{26880}{3} \times \frac{1}{200} =$ 44·8 GALA.

Example 2.—Given particulars as in the above question, ascertain the yarn number for (*a*) Halifax Rural District; (*b*) Jute and Heavy Flaxes: also deduce a formula which is applicable to the solution of yarn problems based on the system grouped under Table II.

Then $\frac{26880}{3} = 8960$ yards per lb.

and $\frac{256 \text{ drams per lb.}}{8960 \text{ yards per lb.}} = \frac{1}{35}$ dr. per yard.

$\therefore \frac{1}{35} \times 80 = 2\frac{2}{7}$ drs. per 80 yards = Counts.

The working may be simplified as follows:—

FORMULA II.

$$\frac{\left\{\begin{array}{l}\text{(Weight of given length}\\ \text{in grains, drams,}\\ \text{deniers, or lbs.)}\end{array}\right\} \text{(unit of length in yds.)}}{\text{Given length of yarn}} = \text{COUNTS.}$$

@ H.R.D. $= \frac{3 \times 256 \times 80}{26880} = \frac{16}{7} = 2\frac{2}{7}$ drams per 80 yds.

(*b*) Jute or Heavy Flax (Spindle)

$= \frac{3 \times 48 \times 300}{26880} = 1{\cdot}6$ lbs. per spindle

Example 3.—Find the counts of one bunch containing 12 bundles of linen yarn which weighs 24 lbs.

Then $\frac{\text{No. of bundles} \times \text{yards per bundle}}{\text{Weight in lbs.} \times \text{yards per lea}} = \text{leas per lb.}$

$\therefore \frac{12 \times 60{,}000}{24 \times 300} = 100$ leas per lb.

or $\frac{12 \text{ bundles} \times 200 \text{ cuts}}{24 \text{ lbs.}} = 100$ leas.

Example 4.—Given 18s lea yarn, find weight in lbs. and ozs. per bundle and also of a spindle.

Then wt. per bundle $= \frac{\text{cuts per bundle}}{\text{cuts per lb.}} = \frac{200}{18} = 11\frac{1}{9}$ lbs.

or weight of bundle $= \frac{60{,}000 \text{ yds. per bundle}}{18 \times 300 \text{ yds. per lb.}} = 11\frac{1}{9}$ lbs.

and $11\frac{1}{9}$ lbs. $\times$ 16 ozs. per lb. $= 177\frac{7}{9}$ ozs.

Also weight of spindle $= \frac{14{,}400 \text{ yds. per spindle}}{18 \times 300 \text{ yds. per lb.}} = 2\frac{2}{3}$ lbs.

and $2\frac{2}{3}$ lbs. $\times$ 16 ozs. $= 42\frac{2}{3}$ ozs.

Example 5.—If 4 cops of 24s cotton weigh $2\frac{3}{4}$ ozs., what is the total length of the yarn?

Then $\frac{\text{yds. per lb.}}{\text{ozs. per lb.}} \times \text{wt. in ozs.} = \frac{840 \times 24}{16} \times 2\frac{3}{4} = 3465$ yds.

Example 6.—Ascertain the length in metres and in yards of 1 oz. of 100 denier net silk.

Then weight of 1 hank of 476 metres or 520 yards

$= 100 \text{ deniers} = \frac{3}{1600} \times 100 = \frac{3}{16} \text{ ozs.}$

and (1) Length in yds. per oz. $= \frac{520 \times 16}{3} = 2773{\cdot}3.$

also (2) ,, metres ,, $= \frac{476 \times 16}{3} = 2538{\cdot}6.$

Equivalent Counts in Different Denominations.

Owing to the fact that yarns produced from different materials and under separate denominations are frequently twisted together for strength and effective purposes, *e.g.*, silk, wool, etc., and also since yarns made in one district are often consigned for use in other localities where a different system of numbering is adopted, it becomes repeatedly necessary to convert any given 'count' into an equivalent count of some other required denomination.

Example 1.—Given 20s worsted yarn, it is required to find its equivalent counts in Cotton, Yorkshire skeins, Galashiels, Hawick and Linen.

(a) Since 20s wtd. $= 20 \times 560$ yds. $= 11200$ yds. per lb. and since in *cotton* there are 840 yds. in one hank,

$\therefore \frac{11200}{840} = 13\frac{1}{3}$ hanks of cotton per lb.

i.e., $13\frac{1}{3}$ counts of cotton represent the same length and weight as 20s worsted.

The process may be simplified thus:—

Formula III.

$$\frac{\text{Given counts} \times \text{yards per hank}}{\text{Yards per hank in required denomination}} = \text{required counts.}$$

(b) In Yorkshire skeins, woollen,

$$\frac{20 \times 560}{256} = 43\tfrac{3}{4} \text{ skeins or counts.}$$

(c) In Galashiels 'cuts,'

$$\frac{20 \times 560}{200} = 56 \text{ 'cuts'—Galashiels.}$$

(d) In Hawick 'cuts.'

$$\frac{20 \times 560 \times 26}{(300 \times 16)} = 60\tfrac{2}{3} \text{ 'cuts'—Hawick.}$$

(e) In Linen 'leas,'

$$\frac{20 \times 560}{300} = 37\tfrac{1}{3} \text{ leas, or cuts.}$$

Example 2.—Given 70s linen and 20s cotton yarns, ascertain the equivalent counts of the former in cotton and the latter in linen.

$$\text{Then 70s linen} = \frac{70 \times 300}{840} = 25\text{s Cotton.}$$

$$\text{and 20s cotton} = \frac{20 \times 840}{300} = 56\text{s Linen.}$$

If it is required to change the denomination of any count of yarn given in Table II, a different method and formula are necessary; *e.g.*,

Example 3.—Given 20s Yorkshire skeins woollen, find its equivalent in the Halifax Rural District, denier and jute denominations.

(a) The Halifax Rural District,

Then 20 hanks per lb. × 256 yards per skein = number of yards per lb.

Also 256 equals the number of drams per lb.

And $\frac{256}{20 \times 256} = \frac{1}{20}$ dram. Weight of 1 yard of 20s Yorkshire skeins.

Again, since the weight in drams of 80 yards represents the counts in Halifax Rural District,

$$\therefore \text{counts} = \frac{1}{20} \times \frac{80}{1} = 4 \text{ drams per 80 yards, or 4s counts.}$$

This may be reduced and simplified thus:

FORMULA IV.

$$\frac{\text{Lbs., drams, grains, or deniers per lb.} \times \text{unit length}}{\text{Yards per lb. of given yarn}} = \text{required counts.}$$

(b) In the 'Denier' System,

$$\left(\frac{1600 \times 16}{3}\right) \frac{\times 520}{\times 20 \times 256} = 866{\cdot}6 \text{ deniers per hank of 520 yds. or counts.}$$

(c) In the 'Jute' System,

$$\frac{1 \times 48 \times 300}{20 \times 256} = 2\tfrac{13}{16} \text{ counts or lbs. per spindle.}$$

Example 4.—Given (a) 16s linen, find the equivalent counts in lbs. per spindle; (b) 20s Yorkshire skein, express the same in terms of the Halifax Rural District System.

$$\text{Then (a) 16s Linen} = \frac{\overset{\text{Yds. per spindle.}}{14400}}{\underset{\text{Yds. per lb.}}{16 \times 300}} = 3 \text{ lbs. per Spindle.}$$

$$\text{And (b) 20s Y. S.} = \frac{\overset{\text{Skeins.}}{80}}{\underset{\text{Yds. per skein.}}{20}} \times \frac{\overset{\text{Yds.}}{16} \times \overset{\text{Drs. per lb.}}{16}}{256} = 4 \text{ Drs. per 80 yds.}$$

Example 5.—If 50 denier net silk has to be reeled into hanks of 840 yards each, to meet the requirements of the manufacturer, what would be the number of hanks per lb.?

$$\text{Then } \frac{\text{Length of denier hank}}{\text{Weight in ozs.}} = \text{yds. per oz.} = \frac{520}{50 \times \frac{3}{1600}}$$

$$\text{And } \frac{\text{yds. per oz.} \times \text{ozs. per lb.}}{\text{yds per ctn. hank}} = \text{Hks. per lb.} = \frac{520 \times 1600 \times 16}{50 \times 3 \times 840} = 105{\cdot}6$$

Short Methods for Finding Equivalent Counts.

Since worsted and cotton counts are very frequently required to be expressed in terms of each other, and because cotton and linen are similarly related the following abbreviated formulæ will be found most useful in practice.

(a) Cotton and Worsted compared.

$$\frac{\text{Cotton}}{\text{Worsted}} = \frac{840}{560} = \frac{3}{2}$$

Consequently 3 yards of 1^s Cotton is equivalent in weight to 2 yards 1^s Worsted, and since their *counts* are in the *inverse* ratio to their weights—

$\therefore$ Worsted count $\times \frac{2}{3}$ = cotton counts,

and cotton ,, $\times \frac{3}{2}$ = worsted ,,

Example 6.—Find the equivalent counts of 10s Cotton in Worsted.

Then 10s cotton $= \frac{10 \times 3}{2}$ 15s worsted

(b) Cotton and Linen compared.

$$\frac{\text{Cotton}}{\text{Linen}} = \frac{840}{300} = 2{\cdot}8$$

$\therefore$ Linen counts $\div$ 2·8 = cotton counts,

and Cotton ,, $\times$ 2·8 = linen ,,

Example 7.—Find the equivalent counts in linen of 10s cotton.

Then 10s cotton = 10 $\times$ 2·8 = 28s linen.

(c) Method of changing from jute, heavy flaxes or hemp to fine linen or lea yarn.

The number of cuts per spindle divided by the number of lbs. per spindle is equivalent to the number of cuts or leas per lb.

Example 8.—Assume a heavy flax yarn weighs 4 lbs. per spindle, to what number of line yarn is this equal?

Then 1 spindle = 48 cuts,
and since each spindle in the question weighs 4 lbs.,

$$\therefore \frac{\text{48 cuts per spindle}}{\text{4 lbs. per spindle}} = 12 \text{ cuts per lb.}$$

Conversely the number of cuts per lb. divided into the number of cuts per spindle is equivalent to the number of lbs. per spindle, thus:—

$$\frac{\text{48 cuts per spindle}}{\text{12 cuts per lb.}} = 4 \text{ lb. per spindle.}$$

EXERCISES.

A. **General.**

1. If 11,200 yards of yarn weigh 1 lb., what counts would represent this length and weight in worsted, woollen, Y. S., cotton and linen?

Ans., 20; $43\frac{3}{4}$; $13\frac{1}{3}$; $37\frac{1}{3}$.

2. How many leas are there in $3\frac{1}{2}$ lbs. of 30s linen, hanks of 2/24 cotton, 60/2 spun silk, and 48s worsted?

Ans., 105; 42; 210; 168.

3. Find the respective weights of 3, 20, 75, 560, and 1800 yards (a) of 4s Halifax Rural District, (b) 12s worsted, (c) 18s Y. S. woollen, (d) 32s linen, and (e) 20s cotton.

Ans., (a) $\frac{3}{20}$; 1; $3\frac{3}{4}$ drs.; $1\frac{3}{4}$; $5\frac{5}{8}$ ozs.; (b) $3\frac{1}{8}$; $20\frac{5}{6}$; $78\frac{1}{8}$ grs.; $1\frac{1}{3}$; $4\frac{2}{7}$ ozs.; (c) $\frac{1}{6}$; $1\frac{1}{9}$; $4\frac{1}{6}$; $31\frac{1}{9}$; 100 drams; (d) $\frac{2}{25}$; $\frac{8}{15}$; 2; $14\frac{14}{15}$; 48 drams; (e) 1·25; 8·3; 31·25; 233·3; 750 grs.

4. Ascertain the weight in lbs. of 100 bundles of 60s line yarn, and 490 hanks of 20s cotton?

Ans., $333\frac{1}{3}$; $24\frac{1}{2}$.

5. State the number of yards there are in 10 lbs. of 35s linen, 16 lbs. of 24s cotton, and 15 lbs. of 30s worsted?

Ans., 105,000; 322,560; 252,000.

6. The weight of a warp whose total length equals 560,000 yards is 80 lbs. What are the counts in Run, Hawick, linen, cotton and worsted?

Ans., $4\frac{3}{8}$; $37\frac{11}{12}$; $23\frac{1}{3}$; $8\frac{1}{3}$; $12\frac{1}{2}$.

7. Given 120 yards each of cotton, spun silk, worsted and linen yarns respectively; assume that the weight of each length of yarn is 50 grains; ascertain the counts in each respective denomination. State also the weight in drams of 4 hanks in each yarn sort?

Ans., 20; 20; 30; 56; $51\frac{1}{5}$; $51\frac{1}{5}$; $34\frac{2}{15}$; $219\frac{3}{7}$.

8. (a) Find the equivalent counts in cotton and linen of 60/2 spun silk, and (b) the equivalent counts in worsted of 40/2 spun silk.

Ans., (a) 60; 168; (b) 60.

9. (a) Find the number of yards of weft in 1 lb. of 20s cotton; (b) find the equivalent counts in worsted for 20s cotton; and (c) what would be the equivalent counts of 45s worsted?

Ans., 16,800; 30; 30.

10. State the weight of 30 bundles of 40s linen yarn and the number of lbs. of 30s cotton required to give the same number of yards?

Ans., 150; $71\frac{3}{7}$.

11. Ascertain the number of spindles of 14s jute yarn that would be required to equal in length 100 lbs. of 14s cotton. State also the weight of the jute yarn?

Ans., $81\frac{2}{3}$; $1143\frac{1}{3}$ lbs.

12. Ascertain the equivalent yarn number of 10s, 25s, 30s, and 40s cotton, in linen,

Ans., 28; 70; 84; 112.

13. Find the equivalent counts of 56 line yarn in cotton and of 2/60s cotton, in linen.

Ans., 20s cotton; 84 leas linen.

14. Given 25 lbs. of 20s cotton yarn and 50 spindles of 5 lb. dry spun flax, what number of bundles of linen yarn are equal to these respective lengths?

Ans., 7 and 12.

15. Find the equivalent counts of 16s, 20s and 2/50s cotton, in linen?

Ans., 44·8; 56 and 70s lea.

16. Find the number of hanks of cotton yarn that would be equal in length to 9 Irish or Scotch hanks and 4 cuts of linen yarn ?

Ans., 40.

17. 30s Continental cotton and linen counts are given, what counts in English worsted, linen and cotton are equivalent ?

Ans., 53·1 ; 99 ; 35·4.

18. Convert the following into worsted counts : 18 Skeins woollen (Yorkshire) ; 100/2 silk ; 2/60s cotton ; also give the number of yards in 20 lbs. of each of these counts.

Ans., $8\frac{8}{35}$; 150s ; 45s ; 92.160 ; 1,680,000 ; 504,000 yards.

19. Find the weight of 20 hanks, of 1000 metres each, in grammes and lbs. of each of the following Continental counts ; (a) 16s worsted, and (b) 25s cotton.

Ans., 1250 ; 400 grammes ; $2\frac{3}{4}$; 14·1 ozs.

B. **Woollen and Worsted.**

1. The weight of a length of 16s worsted yarn is 3 oz., what is its length ?

Ans., 1680 yards.

2. If 160 hanks of worsted weigh $9\frac{1}{2}$ lbs., what are the counts?

Ans, $16\frac{16}{19}$.

3. How many lbs. would there be in 1 gross of hanks of 32s worsted ?

Ans., $4\frac{1}{2}$ lbs.

4. If 270 yards of yarn weigh $13\frac{1}{2}$ drams, what counts in worsted would represent this length and weight ?

Ans.. $9\frac{1}{7}$.

5. If 4800 yards of warp material weigh $\frac{3}{4}$ lb., (a) what are the counts in worsted ? (b) what would be the length of this weight of yarn in each of the following materials : 14s Hawick, 8s Halifax Rural District, and 18s Yorkshire skeins woollen ?

Ans., (a) $11\frac{3}{7}$; (b) 1938 ; 1920 ; 3456 yards.

6. Find the equivalent counts of 2/48s worsted in Y. S. woollen, Galashiels, and the Hawick Systems.

Ans., $52\frac{1}{2}$; $67\frac{1}{5}$; $72\frac{1}{5}$.

7. Ascertain the number of yards of yarn contained in 3 lbs. of 12s Worsted; Gala.; West of England and Y. S. Woollen.

Ans., 20,160; 7,200; 11,520; 9,216.

8. Convert the following into West of England counts; 20s worsted, 36 cut Hawick, and 10s Halifax Rural District.

Ans., 35; $20\frac{10}{13}$; $6\frac{2}{5}$.

9. Find the equivalent counts (a) in worsted of 18s Continental yarn; (b) in Continental of 16s English (worsted) yarn.

Ans., (a) 15·93; (b) 18·09.

10. What is the equivalent count of 24s English worsted in Continental worsted?

Ans., 27·12.

11. (a) If 1 gross of hanks of worsted weighs 8 lb., what is the counts? (b) Find the number of yards in 8 lbs. of 18s Y. S. Woollen; 6 lbs. of 2/24 worsted: 14 lbs. of 30s cut Gala., and in 6 ozs. of 20s worsted.

Ans., (a) 18; (b) 36,864; 40,320; 84,000; 4,200.

12. Ascertain the equivalent Y. S. Woollen counts for the following yarns:—2 threads of 2/40s; 2 threads of 2/30s, and 1 thread of 16s worsted

Ans., 21·9; 16·4; 35.

C. Cotton and Silk.

1. Ascertain the length of yarn in $1\frac{1}{2}$ lbs. each of 30s cotton and 40/2 spun silk yarns.

Ans., 37,800; 50,400 yards.

2. (a) If 3 hanks of cotton weigh $3\frac{1}{2}$ ozs., what is the counts? (b) Ascertain the number of hanks in a bundle (10 lbs.) of 15s cotton. (c) the weight in grains of 3 leas of 60s cotton.

Ans., $13\frac{5}{7}$; 150; 50.

3. (a) Given 7560 yards of cotton, the weight of which is $\frac{3}{4}$ lb.; ascertain the counts. (b) If 4 leas of cotton weigh $24\frac{1}{2}$, 25, 25, $25\frac{1}{2}$ grains respectively, what average number of hanks will weigh 1 lb.?

Ans., 12, 40.

4. Find the equivalent counts of 50s cotton in continental and vice versa of 40s continental cotton in English cotton.

Ans., 42·3; 47·2.

5. Find the equivalent counts in cotton of 100s, 120s, 150s, and 200s artificial legal silk counts.

Ans., 53·16; 44·3; 35·44; 26·58.

6. Find the number of yards per oz. in 2 dram, tram silk.

Ans., 8,000.

7. Given 36,000 yards per oz. of raw silk, what counts in the Denier System would represent this length and weight?

Ans., $7\frac{12}{27}$.

8. Find the denier count of 10,000 yards per oz. raw silk.

Ans., $27\frac{11}{15}$s.

9. Given 32,000 yards of 3 tram China Silk; find the weight in drams.

Ans., 96.

10. If a bundle of spun silk weighs 10 lbs. and has a total length of 512,000 yards, express (a) the size in drams per 1000 yards, and (b) the artificial and legal silk number in half decigrammes per 450 metres.

Ans., 5; 87·2.

11. Ascertain the weight in grains of 1 hank each of 12s, 18s and 2/32s cotton.

Ans. 583·3; 388·8; 437·5.

12. Reduce 60/2 spun silk to its equivalent in net silk dram counts.

Ans., 5.

13. Net silk reeled into hanks of 840 yds. contained 220 such hanks to the lb., what was the equivalent denier number.

Ans., 24.

E. Linen, Hemp and Jute.

1. If a bunch of linen yarn weighs 10 lbs., and contains 3 bundles; what is the lea number?

Ans., 60

2. Ascertain the weight of one bundle each of 30s, 50s, and 80s line respectively.

Ans., $6\frac{2}{3}$; 4; $2\frac{1}{2}$.

3. Find the counts of the following yarns: (a) 200 bundles, weighing 500 lbs.; (b) 3 bundles, weighing 15 lbs.; (c) 4 hanks, weighing 3 lbs., and (d) 6 cuts, weighing 2 ozs.

Ans., 80; 40; 16; 48.

4. Ascertain (a) the cuts per lb. of 40s, 50s, and 80s lea; (b) the cuts in 10 lbs. of 110s line; (c) the lbs. per spindle for 8s line yarn.

Ans., 40; 50; 80; 1100; 6.

5. A quantity of jute yarn counts 6 lbs. per spindle, and weighs $\frac{3}{4}$ lb., what is the length in yards.

Ans., 1800.

6. A bale of 80s linen yarn weighs 2 qrs. 26 lbs., what number of bundles does it contain?

Ans., 32·8.

7. If 300 bundles of linen yarn weigh 16 cwt., 3 qrs., 27 lbs., what is the lea number?

Ans., 31·5.

8. (a) If one cut of linen yarn weighs 140 grains, find the lea number. (b) Ascertain the weight in grains of 1 lea of 35s, 70s, and 90s linen.

Ans., 50; 200; 100; $77\frac{7}{9}$.

9. (a) What is the standard weight of 200 bundles of 150s line yarn? (b) Find the equivalent in lbs. per spindle of 20s lea, and (c) the number of leas in 32s bundles of 120s linen.

Ans., $266\frac{2}{3}$; $2\frac{2}{5}$; 6400.

10. (a) Find the number of yards in 60 bundles of 25s lea, and ascertain how many spindles of 10s jute yarn would be required to equal this length? (b) State the number of yards in 90 spindles of 16s dry spun flax.

Ans., 3,600,000; 250; 1,296,000.

11. (a) How many yards are there in 24 bundles of 90s linen? (b) State the number of spindles of 16s jute which are required to equal in *weight* 1 lb. of 18s linen yarn? (c) State the number of spindles of 14s jute yarn that would be required to equal this *length* of 18s lea.

Ans., 1,440,000; $\frac{1}{16}$; $\frac{3}{8}$.

12. Ascertain the weight in lbs. and the length of 3 bundles, and also of 4 spindles of 18s lea yarn.

Ans., $33\frac{1}{3}$; 180,000; $10\frac{2}{3}$; 57,600.

13. If a 56 lb. bundle of 8 lb. jute yarn reels 5% short in length, ascertain the actual length and the lbs. per spindle.

Ans., 95,760; 7·6.

14. An order for 5,000 lbs. of 60s English or French short reeled linen is placed; calculate the number of such hanks that will be required.

Ans., 60,000.

15. Find the weight in kilogrammes of 100 bundles of 80s linen yarn.

Ans., 113·6.

16. Find the weight in lbs. and grammes of 1 French Pacquet of 56s linen yarn.

Ans., 21$\frac{3}{7}$ lbs.; 9718 grammes.

17. (a) Find the weight of a 12 bundle bunch of 120s linen yarn; (b) If 45 hanks weigh 3 lb., what is the lea number?

Ans., 20; 180.

18. The number of bundles per bunch for 20s, 30s, 75s, 100s and 150s linen yarn is given as 1$\frac{1}{2}$; 3; 6; 9 and 12 respectively. Find the respective weights of each.

Ans., 15; 20; 16; 18; 16 lbs.

CHAPTER II.

Resultant and Average Counts.

When two or more single threads are folded or twisted together, the resultant thread is usually designated as *twisted* or *folded*; but if these twisted threads are again folded as is the case for harness cords, shoe threads, cords and strands requiring great strength or special effect, they are then said to be 'cabled.'

NOTE.—When *resultant counts* are required, the threads are supposed to be twisted together, whereas when *average counts* are required, it is assumed that the threads are contiguous in the woven cloth and retain their respective individualities.

RESULTANT COUNTS OF LIKE DENOMINATION.

When two or more threads are twisted or folded together it is then necessary to find the number of hanks or other unit per lb. of the combined thread. This process is known as *finding the resultant counts.*

Example 1.—If 2 threads of 20s worsted are twisted together, the number of hanks of the combined thread will equal 20 per every 2 lbs., and consequently, 10 hanks per lb., which latter number represents the 'resultant counts.'

Example 2.—If one thread of 20s cotton and one thread of 60s cotton are twisted together, what are the resultant counts of the twisted thread?

Supposing there is no variation in the take-up of the length of each yarn during the twisting operation, the same length of each material will be required.

For the purpose of illustration, when 60 hanks of 60s cotton are used, 60 hanks of 20s cotton will also be taken, and when these have been twisted together we shall have only 60 hanks, but 60 of the former count weigh 1 lb., while 60 hanks of the latter weigh 3 lbs. Consequently, the 60 hanks of the twisted thread equal 4 lbs. or

$\frac{60}{4} = 15$ hanks per lb., or the resultant counts.

The above may be stated thus:—

60 hanks of 60s cotton = 1 lb.
60 hanks of 20s cotton = 3 lbs.
60 hanks of twisted thread = 4 lbs.

$\therefore \frac{60}{4} = 15 =$ resultant counts.

The foregoing may be reduced to a simple formula, which will be found applicable for finding the resultant counts of any number of threads of *like* denomination which are twisted together.

N.B.—Threads of various denominations must be reduced to a *like* denomination

Formula V.

Select the highest count and divide it by itself and each of the given counts; the quotient in each case will then represent the relative weight of each thread in lbs.; then divide the selected count by the sum of these weights, and the answer will equal the Resultant Counts.

Example 3.—Find the resultant counts of 20s, 30s, and 60s worsted thread twisted together.

By formula V.:—

Hanks ÷ counts = relative weight in lbs.

60	÷	60	=	1
60	÷	30	=	2
60	÷	20	=	3

60 hanks of twist = 6 lbs.

$\therefore \frac{60}{6}$ = 10 hanks per lb. = resultant counts.

Short Method of finding Resultant Counts.

When only two counts are twisted together, a shorter method is adopted in practice, but it cannot be conveniently adopted to the solution of twist yarns of more than two threads.

Formula VI.

Divide the product of the two given counts by their sum.

Example 4.—Given 10s worsted and 5s worsted, find the resultant counts.

By formula VI.:—

$$\frac{10 \times 5}{10 + 5} = \frac{50}{15} = 3\tfrac{1}{3} \text{ counts.}$$

Proof.—It will readily be admitted as an axiom that the *product* of the counts and weight of like materials of equal length are equal; *e.g.* given equal lengths of 10s and 5s worsted, the relative weight of 5s is 10 lbs. when the weight of 10s worsted is 5 lbs. or in inverse proportion to their counts. The total weight of these two counts of given length = (10 + 5) 15 lbs. Let x equal the resultant counts of 10s and

5s worsted. Then since x counts weighing 15 lbs. is of equal length to 5s or 10s weighing 10 lbs. and 5 lbs. respectively, it therefore follows that $(10 + 5)\,x =$ 5s worsted $\times$ 10 lbs., or 10s worsted $\times$ 5 lbs.

$$\therefore x = \frac{5 \times 10}{(10+5)} = 3\tfrac{1}{3} \text{ counts.}$$

which is the same as given at formula VI.

Example 5.—Find the resultant number of leas per lb. of 75s and 50s linen yarn twisted together.

By formula VI. :—

$$\frac{75 \times 50}{75 + 50} = 30 \text{ leas per lb.}$$

Resultant Counts for Yarns in Table II.

To find the resultant counts for two or more folded yarns, such as jute, dry spun flaxes, American Grain System and Halifax Rural Count all that is required is to add the weights together for each respective sort and unit length, *e.g.*

(1) If 2, 3 and 4 lbs. per spindle of jute are folded together,
The resultant counts = 2 + 3 + 4 = 9 lbs. per spindle.

(2) Also if 2 and 4 lbs. of dry spun flax are folded together,
The resultant counts = 2 + 4 = 6 lbs. per spindle.

(3) If two threads of 6 dram woollen (80 yds.) are folded together,
The resultant counts = 6 + 6 = 12 drs. (80 yds.)

(4) In the grain system, if 15 and 20 grain yarn be twisted together,
The resultant counts = 15 + 20 = 35 grains.

Resultant Counts of Mixed Denominations.

When twist yarns are composed of different materials, or are given in different denominations, it is necessary to first reduce all to any one of the given denominations before any attempt is made to find the resultant counts.

Example 1.—Given a compound twist thread which is made up of one thread 24s black worsted; one thread 16s slate worsted; one thread 32/2 spun silk, red. Find the resultant counts in worsted.

Then 32/2 spun silk $= \frac{32 \times 840}{560} = 48$s worsted.

Then by formula V.:—

$$\begin{array}{rcrcr} 48 & \div & 48 & = & 1 \\ 48 & \div & 24 & = & 2 \\ 48 & \div & 16 & = & 3 \\ \hline 48 \text{ hanks} & & & = & 6 \text{ lbs.} \end{array}$$

$\therefore \frac{48}{6} = 8$ hanks per lb. = resultant counts.

Example 2.—Ascertain the resultant counts in linen of 70s lea yarn twisted with 50s worsted.

50s worsted $= \frac{50 \times 560}{300} = \frac{280}{3}$ linen.

And by formula VI.:—

$$\frac{70 \times \frac{280}{3}}{70 + \frac{280}{3}} = \frac{70 \times \frac{280}{3}}{\frac{490}{3}} = \frac{70 \times 280 \times 3}{3 \times 490} = 40\text{s lea.}$$

Example 3.—Given 24s cotton and 24s worsted twisted together; find the resultant counts in cotton.

Then 24s worsted $= \frac{24 \times 560}{840} = 16$s cotton.

And resultant counts $= \frac{24 \times 16}{24 + 16} = 9{\cdot}6$s cotton.

Solution of Unknown Count in a Compound Twist Thread.

Occasionally a spinner or manufacturer has given the counts of his compound twist thread and one or

more of the threads which go towards its composition; it then becomes necessary to find the size of the unknown thread which together with the given count makes the required component twist yarn.

Example 1.—Assume a twist thread must be equal to 20s worsted, of which one of the component threads is 60s worsted; what must be the counts of the second thread?

By the application of formula VI., already proved, we may solve not only the above problem, but also explain an additional formula which is much shorter and of more frequent application.

Let x = the counts of the second thread.

Then by formula VI.:

$$\frac{60x}{60 + x} = 20\text{s resultant counts.}$$

By multiplying across we obtain

$$60x = 20\ (60 + x)$$

$$60x = 20 \times 60 + 20x.$$

$$60x - 20x = 20 \times 60.$$

$$\therefore x = \frac{20 \times 60}{60 - 20} = 30\text{s counts of second thread.}$$

It should be observed that the size of the second thread is always equal to the product of the two given counts (first thread and resultant counts) divided by their difference, and this being always the case, the result may be expressed in the following recognised formula:—

FORMULA VII.

Divide the product of the two counts by their difference, thus:—

$$\frac{\text{1st count} \times \text{resultant counts}}{\text{1st count} - \text{resultant counts}} = \text{count of second thread.}$$

Example 2.—With what size of cotton must a 45s cotton yarn be twisted to produce a resultant count of 20s cotton?

By formula VII. :—

$$\frac{45 \times 20}{45 - 20} = 36\text{s cotton.}$$

Example 3.—A twist thread is composed of 25 Y. S. woollen and a second thread in Galashiels. The combined thread is equal to 16s Galashiels. What is the grist of the second thread?

N.B.—When more than two threads are used in the composition of a twist thread, and when only one of them is unknown, it is necessary to first reduce all the known threads to one resultant count before attempting to find the unknown count, which may afterwards be accomplished by the aid of formula VII.

Then 25 Y. S. $= \frac{25 \times 256}{200} = 32\text{s}$ counts Galashiels.

By formula VII. :—

$$\frac{32 \times 16}{32 - 16} = 32 \text{ Galashiels or grist of the 2nd thread.}$$

Example 4.—Required the worsted number, which when twisted with 40s lea yarn will equal 28s linen.

By formula VII. :—

$$\frac{40 \times 28}{40 - 28} = \frac{280}{3} \text{ Lea, and } \frac{280}{3} \times \frac{300}{560} = 50\text{s Worsted.}$$

Example 5.—A twist thread is equal to 15s worsted counts; it is composed of 1 thread 36s black worsted, a second thread of 40/2 spun silk and a third thread of slate-coloured worsted. Find the counts of the last-named yarn.

Then 40/2 spun silk $= \frac{40 \times 840}{560} =$ 60s worsted,

and $\frac{60 \times 36}{60 + 36} = \frac{45}{2}$ worsted.

Then by formula VII. :—

$$\frac{22\frac{1}{2} \times 15}{22\frac{1}{2} - 15} = 45\text{s worsted.}$$

That is, 45s worsted, 36s worsted and 40/2 spun silk, all twisted together are equal to 15s worsted counts.

Whenever it is required to find the size of any dry spun flax, jute or Halifax rural woollen count to twist with any known size of yarn to produce some other specific count or weight per spindle or other unit of length as in Table II., it is evident that all that is necessary is to subtract the weight of the given single yarn from that of the compound twist thread when the result will equal the required size of the other single yarn thus :—Let it be required to fold 7s jute yarn to make 15 lbs. per spindle.

Then 15 − 7 = 8 lbs. per spindle.

Resultant Counts—When Lengths Vary.

Fancy twists of such types as spiral, corkscrew, loop or knop yarns, etc., are produced from different lengths of thread, and consequently, the counts do not represent their true relative lengths, but are modified according to the variation in 'take-up' of material.

Example 1.—A spiral twist thread is made from 2/56s Botany and 1/7s Botany—10 inches of the former being required to every 7 inches of the latter thread. What is the resultant counts ?

(a) Then 2/56s Botany equals 28s worsted counts.

(b) And the relative length required of this finer count is $\frac{3}{7}$ more than that of the coarser.

(c) Further, if no variation in length occurred, we should require the same number of hanks of each; (the term hank being simply used for convenience, since it represents a fixed length). If, for example, we select 28 hanks, the number of hanks in 1 lb. of 2/56s Botany, it is evident we shall require $\frac{3}{7}$ more hanks or length of this count to allow for the extra take-up thus: $28 + (\frac{3}{7}$ of $28) = 40$ hanks (or 28 hanks each 800 yards long).

(d) And weight of 40 hanks of 28s worsted $= 1\frac{3}{7}$ lbs.

(e) Also weight of 28 hanks of 7s worsted $= 4$ lbs.

(f) When these are twisted together the number of hanks will then equal 28 for the above total weight of $(1\frac{3}{7} + 4) = 5\frac{3}{7}$ lbs.

$$\therefore \frac{28}{5\frac{3}{7}} = 5\frac{3}{19} \text{ hanks per lb.} = \text{resultant counts.}$$

The foregoing is simplified and expressed in the following formula:—

Formula VIII.

(1) Select the highest count or number of hanks per lb. from one of the given counts.

(2) Add the additional length expressed in hanks for take-up in twisting if any. The result equals the relative length of each in hanks.

(3) Divide the relative number of hanks of each by the respective counts. The result equals the relative weights.

(4) Divide the number of hanks per lb. of selected count by the sum of the relative weights—the quotient equals the resultant counts.

Thus in the above example,

Hanks per lb.	+	extra length	=	relative length expressed in hanks	÷	counts	=	rel. weight lbs.
28	+	($\frac{3}{7}$ of 28)	=	40	÷	28	=	$1\frac{3}{7}$
28	+	0	=	28	÷	7	=	4

28 hanks of twist thread weigh = $5\frac{3}{7}$ lbs.

$\therefore \frac{28 \times 7}{38} = 5\frac{3}{19}$ hanks per lb. = resultant counts.

Formula VIIIa.

Second Method.—For fancy twist yarns, the respective length of each component thread may be used as the dividend for each yarn sort, in lieu of the highest count as in formula VIII.

(1) Each respective length may, for convenience, be expressed in hanks or other equivalent.

(2) Each dividend must then be divided by its respective count of yarn; the results equal the relative weights of each sort of yarn.

(3) Then if the relative unit length of the compound twist thread be divided by the sum of the relative weights, the quotient will be equivalent to the number of hanks per lb. or other equivalents, thus:—

Rel. lengths ÷ Respective cts. = Rel. weights

7	÷	7	=	1
10	÷	28	=	$\frac{5}{14}$

7 hanks of unit twist weigh $1\frac{5}{14}$ unit weights.

$\therefore$ Resultant counts $= \frac{7 \times 14}{19} = 5\frac{3}{19}$.

Formula VIIIb.

Third Method.—The relative weight of each yarn sort may be first ascertained for any common length of yarn as by Formula V. Then each relative weight may be increased *pro rata* to its relative length over the unit length of the compound twist thread, thus:—

Highest count ÷ Counts = Rel. wt. × relative length

28	÷	28	=	1 × $\frac{10}{7}$	=	$1\frac{3}{7}$
28	÷	7	=	4 × 1	=	4
28 hanks weigh				... ...		$5\frac{3}{7}$

$\therefore \frac{28}{5\frac{3}{7}} \times 7 = 5\frac{3}{19}$ hanks per lb.

Example 2.—A knop yarn is made from 1/20s cotton and 36s worsted, 3 inches of worsted are required to every 2 inches of cotton, the latter thread being practically straight. Find the number of hanks per lb. of the twisted thread in worsted.

Then 20s cotton $= \frac{20 \times 840}{560}$ or $\frac{20 \times 3}{2} = 30$s worsted.

Also, one half more hanks or length of 36s worsted is required.

By formula VIII.:—

Hanks per lb.	+	extra length	=	relative length expressed in hanks	÷	counts	=	rel. weight lbs.
36	+	($\frac{1}{2}$ of 36)	=	54	÷	36	=	$1\frac{1}{2}$
36	+	0	=	36	÷	30	=	$1\frac{1}{5}$
36 hanks of twist thread weigh						...		$2\frac{7}{10}$ lbs.

$\therefore \frac{36}{2\frac{7}{10}} = 13\frac{1}{3}$ hanks per lb. = resultant counts.

Example 3.—A crewel yarn is made from 20s and 16s worsted, 12 inches of the former and 11 inches of the latter are required to produce 10 inches of twist.

What number of hanks per lb. does the twist thread contain ?

Then of the 20s worsted $\frac{1}{5}$ more length is required than the actual length of the twist yarn.

And of the 16s worsted $\frac{1}{10}$ more length is required than the actual length of the twist yarn.

Then by formula VIII. :—

20	+	($\frac{1}{5}$ of 20)	=	24	÷	20	=	$1\frac{1}{5}$ lbs.
20	+	($\frac{1}{10}$ of 20)	=	22	÷	16	=	$1\frac{3}{8}$ lbs.

20 hanks of twist thread weigh ... $2\frac{23}{40}$

$\therefore \frac{20}{2\frac{23}{40}} = 7{\cdot}767$ resultant counts.

By formula VIIIA. :—

Rel. length	÷	Respective counts	=	Rel. weight
12	÷	20	=	$\frac{3}{5}$
11	÷	16	=	$\frac{11}{16}$

10 hanks unit lengths weigh ... $\frac{103}{80}$

$\therefore \frac{10 \times 80}{103} = 7{\cdot}767$ approx. $7\frac{3}{4}$ resultant counts.

Example 4.—If a fancy twist is required to average 7 hanks per lb., worsted counts, what worsted yarn number must be twisted with 16s mohair, when 11 inches of the required count are required to 15 inches of the given count, to produce 10 inches of twist.

Let x = the worsted yarn number.

Then by formula VIIIA. :—

Rel. len.	÷	Counts	=	Rel. wt.
11	÷	x	=	$\frac{11}{x}$
15	÷	16	=	$\frac{15}{16}$

Unit length 10 hanks of twist $= \frac{11}{x} + \frac{15}{16} = \frac{176 + 15x}{16x}$

$$\therefore \frac{10 \times 16x}{176 + 15x} = 7 \text{ hanks per lb.}$$

$$\text{And } 160x = 7(176 + 15x) = 1232 + 105x$$

$$= 160x - 105x = 1232$$

$$\therefore \quad x = \frac{1232}{55} = 22{\cdot}4$$

Or alternatively,

15″ of 16s contracted to 10″ in the twist thread =

$$\frac{16 \times 10}{15} = \frac{32}{3} \text{ hanks per lb.}$$

By formula VII.:—

$$\frac{\frac{32}{3} \times 7}{\frac{32}{7} - 7} = \frac{224}{11}$$ Hanks per lb, of the required count in contracted form.

Then 10″ of the contracted thread when extended to its original length of 11″

$$= \frac{224}{11} \times \frac{11}{10} = 22{\cdot}4 \text{ Counts.}$$

Average Counts of Like Denomination.

When two or more yarns of various sizes are used side by side in the same fabric, or when several hanks or leas taken from a quantity of yarn are found to be of different weights, it is frequently necessary and advantageous to determine the 'average counts,' *i.e.*, the count of yarn which will represent the same weight and length for the combined number of the several yarns employed in the given woven fabric.

Example 1.—Suppose a warp is composed of alternate threads of 20s and 10s worsted respectively; equal lengths of each yarn would be required, so assume that 20 hanks of 20s worsted are used, then also 20 hanks of 10s worsted are wanted; total 40 hanks. The

weight of the former equals 1 lb. while that of the latter equals 2, which gives an average of

$$\frac{40 \text{ hanks}}{3 \text{ lbs.}} = 13\tfrac{1}{3} \text{ hanks per lb.} = \textit{average counts.}$$

Example 2.—A cloth is woven with two threads of 60s cotton and one thread of 20s cotton. What is the average count?

Since the given counts are in the same denomination, and assuming equal lengths of each thread are required, then, if 60 hanks be selected as the unit length there will be two lengths of 60 hanks each of 60s and one length of 60 hanks of 20s.

Further, the weight of (60×2) hanks of 60s $= 2$ lbs.
And the weight of 60 hanks of 20s $= 3$ lbs.
The total number of hanks $= (60 \times 2) + 60 = 180$.
The weight of these hanks $= 2 + 3 = 5$ lbs.

$\therefore$ The average number of hanks per lb. $= \frac{180}{5} = 36$.

This process is best expressed in the following formula, which will be found to admit of general application.

FORMULA IX.

(1) Select the highest count.

(2) Multiply it by the number of threads of each count in one repeat of the pattern.

(3) Divide each product separately by the given counts.

(4) Divide the sum of these quotients *into* the total number of hanks.

The answer equals the average counts.

Example 2.—A woven fabric contains two threads of 2/60s, two of 2/40s, and one of 12s cotton counts. What is the average count?

Then by formula IX. :—

Hanks	×	threads	=	total hanks	÷	counts	=	relative weights.
30	×	2	=	60	÷	30	=	2 lbs.
30	×	2	=	60	÷	20	=	3 lbs.
30	×	1	=	30	÷	12	=	$2\frac{1}{2}$ lbs.
				150 hanks weigh				$7\frac{1}{2}$ lbs.

$\therefore \frac{150}{7\frac{1}{2}} = 20$ hanks per lb. = average count.

Example 3.—If from a quantity of cotton 4 leas are reeled, and when weighed give the following respective results, 34, $34\frac{1}{2}$, $35\frac{1}{2}$ and 36 grains, what is the average number of hanks per lb. ?

Solution : 1 lea weighs 34 grains.
1 ,, ,, $34\frac{1}{2}$,,
1 ,, ,, $35\frac{1}{2}$,,
1 ,, ,, 36 ,,
4 leas weigh 140 grains.

And since 4 leas = $\frac{4}{7}$ of one hank, then the weight in grains of $\frac{4}{7}$ of one hank ÷ into the weight of $\frac{4}{7}$ lb. = the average hanks per lb.

Thus,

$$\frac{\frac{4}{7} \text{ lb.}}{\text{Weight of } \frac{4}{7} \text{ hank}} = \frac{4000 \text{ grains}}{140 \text{ grains}} = 28\tfrac{4}{7} \text{ average hanks per lb.}$$

Average Counts of Mixed Denomination.

Example 1.—Assume a fabric is woven with two threads of 40s cut Galashiels, one thread of 2/30s cotton, and 2/60s worsted. Find the average count in worsted.

First, resolve each system into one of the given denominations ; in this example worsted is demanded.

Then 40s cut Gala. $= \frac{40 \times 200}{560} = \frac{100}{7} = 14\frac{2}{7}$ worsted.

and 2/30s cotton $= \frac{15 \times 840}{560} = 22\frac{1}{2}$ worsted.

Then by formula IX.:—

	Hanks	×	thread	=	hanks	÷	counts	=	rel. weight.
Worsted	30	×	1	=	30	÷	30	=	1 lb.
Cotton	30	×	1	=	30	÷	$22\frac{1}{2}$	=	$1\frac{1}{3}$ lbs.
Galashiels	30	×	2	=	60	÷	$14\frac{2}{7}$	=	$4\frac{1}{5}$ lbs.

120 hanks weigh $6\frac{8}{15}$ lbs.

$$\therefore \frac{120}{6\frac{8}{15}} = 18{\cdot}36 \text{ average count.}$$

EXERCISES.

A. General.

1. (a) Give resulting counts of 36s, 40s, and 60s yarn twisted together; (b) State the hanks per lb. of 18s and 24s folded yarn.

Ans., $14\frac{2}{5}$; $10\frac{2}{7}$.

2. A cloth consists of four threads of 80s, three of 60s and one of 16s. Find the average count.

Ans., $49\frac{3}{12}$.

3. A thread is composed of two threads 30s worsted and one thread of 60/2 silk. Find the resulting counts in worsted.

Ans., $12\frac{6}{7}$ counts.

4. A three-fold twist yarn is composed of 36s worsted, 60s lea linen and 80 spun silk. Find the resultant counts in worsted and also in linen.

Ans., 15s worsted; 28 linen.

5. (a) What would be the resulting counts of 60s spun silk and 30s worsted twisted together? Answer in worsted. (b) What would be the resulting counts in silk of 30s worsted and 60s spun silk twisted together?

Ans., $22\frac{1}{2}$; 15s.

6. A twist thread is composed of one thread 30s worsted, one of 40s cotton, and a third thread of silk Find the counts of the silk thread, assuming that the compound thread is equal to 18s worsted.

Ans., 120 spun silk.

7. A twist yarn which is equal to 8s worsted is composed of 2/60 black worsted, 30/2 spun silk and a third thread of Y. S. woollen. What is the count of the last named yarn?

Ans., $31\frac{1}{2}$ skeins.

8. What counts woollen should be twisted with a 60/2 spun silk to make a resultant counts equal to 30 Y. Skeins woollen?

Ans., $35\frac{35}{89}$ Y. S. woollen.

9. A 3-ply thread is made by twisting the following yarns: one thread $10\frac{1}{2}$ run woollen, one thread 30s worsted, one thread 20s cotton. What would be the equivalent counts of the compound thread in (a) a single cotton, (b) a single worsted, and (c) a woollen thread (Run system)?

Ans., (a) $6\frac{3}{5}$s, (b) 10s, (c) $3\frac{1}{2}$s.

10. A loop yarn is made up of two threads of 2/32s white cotton and one thread of 24s red worsted, two yards of worsted are used to each yard of cotton. Find the number of hanks per lb. of the compound thread in worsted.

Ans., 6.

11. A loop yarn has a resultant count of 4s cotton. It is made up of two threads of 2/28s black cotton and a grey thread in worsted. There are two yards of this last thread used to each yard of the cotton, find the counts of the worsted.

Ans., 28s.

12. A loop yarn is composed of two threads of 24s black mohair, one thread of 2/40s red cotton, and one thread of 8s green cotton. 24, 12 and 10 inches of these respective counts produce 9 inches of twist. Find the resultant counts in cotton.

Ans., 1·86.

13. Find the resultant worsted counts of a fancy twist composed of 2/60s cotton, 2/40s worsted and 18 mohair.

Ans., 8·37 worsted.

14. Find the average counts in worsted and cotton of a warp composed of 6 ends of 2/20s worsted, 2 ends of 2/12s cotton, and 1 end of 20s worsted and 20s cotton twisted together.

Ans., 9·9 worsted; 6·6 cotton.

B. **Wool and Worsted.**

1. (a) What would be the resulting counts of 30s and 60s worsted twisted together, and (b) of 30s and 20s woollen twisted together?

Ans., 20s; 12s,

2. (a) Find the resulting counts of 80s, 60s, 40s, and 20s worsted twisted together; (b) Find the resultant counts of 20s, 32s, and 40s worsted twisted together.

Ans., $9\frac{3}{5}$; $9\frac{7}{17}$.

3. Find the average counts of a cloth made alternatively with one end of 16s and one end of 32s worsted.

Ans., $21\frac{1}{3}$.

4. A cloth is woven with one pick of 24s mohair and one pick of 16s Y. S. Woollen. What is the average counts in woollen?

Ans., $24\frac{1}{2}$.

5. (a) When a cloth consists of four threads of 80s, two of 40s, and one thread of 16s worsted, what is the average count? (b) What is the average count of two threads of 40s and one thread of 16s worsted?

Ans., $43\frac{1}{13}$; $26\frac{2}{3}$.

6. Give the resultant counts of a compound thread made by twisting one thread of 21s worsted, one thread of 42s worsted, and one thread of 21s Y. S. woollen. Answer to be in the last named system.

Ans., $12\frac{27}{59}$.

7. What counts should be twisted with 20s cut Galashiels to make it equal to 8s cut Galashiels?

Ans., $13\frac{1}{3}$.

8. A fancy twist yarn is composed o 48s worsted, 35 Y. S., and 64/2 spun silk. Find the resultant counts in Y. S.

Ans., $23\frac{1}{3}$.

9. Find the yards per dram and resultant counts in worsted of a gimp yarn composed of 2s crossbred roving, 2/30s worsted and 2/30s worsted for binder. The relative and respective lengths are 54, 41 and 48, and twist 40.

Ans., 2·65; 1·21.

10. A spiral yarn is made by twisting a 2/60s Botany with a 1/8s Botany. If 48 inches of the former are required to each yard of the latter, what is the number of hanks per lb. of the combined thread?

Ans, 5·9.

C. Cotton and Silk.

1. If a thread of 16s and a thread of 40s single cotton be twisted together, what will be the resultant counts ?

Ans., $11\frac{3}{7}$.

2. How many hanks would there be in 1 lb. of 2-ply yarn made by twisting one thread of 24s and one thread of 30s cotton together ?

Ans., $13\frac{1}{3}$ cotton.

3. Given 36s Continental cotton counts, find the resultant counts when twisted with 60/2 spun silk. Answer to be in English cotton counts.

Ans., 24 9.

4. Having 40s cotton yarn and wishing to twist it with another yarn to make it 24s, what number would you employ ?

Ans., 60s counts.

5. The warp for a repp fabric is composed of 2 threads of 2/32s mercerised cotton and one thread of 2/60s cotton. Ascertain the average counts.

Ans., 19.

6. A cotton warp is composed of two-thirds of 50s twist, one-fourth of 20s twist, and one-twelfth of 10s twist. Find the average counts of twist for the whole warp.

Ans., $29\frac{1}{4}$.

7. A fancy loop yarn is composed of two threads of 1/40s white cotton, two threads of 1/40s red cotton, and two threads of 2/100s black cotton. The relative lengths of material used are 8″, 9″, and 4″ respectively. Find the resultant counts. The last thread is straight.

Ans., 4.

8. Find the resultant count of 10, 20, and 40 cotton, and the weight in grains of one lea of the folded yarn.

Ans., $5\frac{5}{7}$; 175.

9. If three leas of cotton, reeled from a parcel of yarn, weigh respectively $19\frac{1}{2}$, 20, and $20\frac{1}{2}$ grains, find the average number of hanks per lb.

Ans., 50.

E. Linen and Jute, &c.

1. (a) Find the resultant lea number of 40s and 60s linen twisted together; (b) What number of leas will there be in a lb. of 50s and 90s linen twisted together?

Ans., 24; $32\frac{1}{7}$.

2. (a) How many cuts are there in 1 lb. of 2-ply yarn made by twisting 24s and 30s linen together? (b) Find the resultant counts, in linen, when one thread of 40s linen and one thread of 10s cotton are twisted together. (c) A resultant union twist yarn is equal to 14s linen, the known thread is 28s linen, find the size of the cotton thread.

Ans., $13\frac{1}{3}$; $16\frac{1}{2}$; 10.

3. What are the equivalent counts in (a) linen yarn scale, (b) dry spun flax scale, of a twisted thread composed of the following:—2 lbs. of dry spun flax, 15s cotton, and 30s linen?

Ans., 10; 4·8 approx.

4. A three-fold linen thread counts 30 leas to the lb. If the amount of contraction due to twisting is 10% what is the average lea number of the single threads?

Ans., 100.

5. Find the resultant lea counts of a six-fold 'cabled' linen thread composed as follows:—50s lea yarn having eighteen turns per inch to the left, *i.e.*, in the opposite direction from which it is spun, afterwards two folded with thirteen turns per inch to the right and finally three of such strands are cabled with ten turns per inch. Shrinkage in length to be ignored.

Ans., $8\frac{1}{3}$ counts.

6. Find the resultant counts in lbs. per spindle of a 3-fold lea cabled harness cord (written thus: 30/9) and also of a 30/12 cabled harness cord made up of 4-ply, 3-ply 30s lea.

Ans., 14·4 lbs.; 19·2 lbs.

7. A union cloth is required to be made from 35s lea warp and a twist weft yarn, composed of cotton and linen, the weight and length of each thread being approximately the same; the folded yarn is equal in size to that of the warp. Find the linen and cotton counts which compose weft.

Ans., 70s linen; 25s cotton.

CHAPTER III.

Relative Weights and Cost of Twist Yarns.

Relative Weights of Component Threads in Twist Yarns.

When Lengths are Equal.

Obviously, for all systems given under Table I, when any twist threads are made up of two threads of different thickness, the weight of each count will be different. The counts of yarn as already demonstrated indicate the relative weights of yarn for some fixed length, which weight decreases as the number of counts increase and *vice versa;* hence, the weights of yarns vary in the inverse ratio of their counts, thus :—

Example 1.—If 30s and 15s counts are folded together, what would be the weight of each in a total weight of 60 lbs. of twist?

Then, according to the above reasoning, 30 units of weight of 15s would contain the same length as 15 units of weight of 30s counts; or, for each 30 lbs. of 15s we should require 15 lbs. of 30s. Then, out of a total weight of 45 lbs. there would be 30 lbs. of 15s and 15 lbs. of 30s, and by simple proportion the weight of each count in 60 lbs. of twist may readily be found thus :—

As $45 : 60 :: 30 : x$, where x = the weight of 15s counts.

$$= \frac{60 \times 30}{45} = 40 \text{ lbs. of 15s}$$

$$\therefore 60 - 40 = 20 \text{ lbs. of 30s.}$$

or, $\frac{60 \times 15}{45} = 20$ lbs. of 30s.

The same may be expressed in a simple formula for use in practice, thus :—

FORMULA X.

To find the weight of each count, in a given weight of twist yarn,

(a) $\frac{\text{Given weight} \times \text{lowest count}}{\text{Sum of the two counts}} = \text{weight of highest count}$

(b) $\frac{\text{Given weight} \times \text{highest count}}{\text{Sum of the two counts}} = \text{weight of lowest count}$

When only two counts are given the above formula supplies a ready means of determining the respective weight of each count in a given weight, but when the twist yarn is composed of several threads, some other method of solution is necessary.

Formula V. (chapter II.) not only helps to find the resultant counts but also shows the relative weight of each count, from which their respective weights in any given total may be obtained; thus, in the above example.

By formula V. :—

Hanks	÷	Counts	=	Relative weight in lbs.
30	÷	30	=	1
30	÷	15	=	2

30 hanks of twist weigh 3 lbs.

Then it is very clear that out of every 3 lbs. of a tota. weight, there is a relative weight of 1 lb. of 30s and 2 lbs. of 15s. Hence, it follows that the respective weight of each count of yarn required to make a twist of indicated total will be pro rata to the relative weights.

Thus :— $\frac{60 \times 2}{3}$ = 40 lbs. of 15s

and $\frac{60 \times 1}{3}$ = 20 lbs. of 30s

or as previously shown.

The whole collected into one formula may be expressed as follows :—

FORMULA XI.

First part, exactly as formula V.

Second part,

$$\frac{\text{Required weight of twist} \times \text{relative weight of respective counts}}{\text{Sum of relative weights}} = \text{weight of respective counts.}$$

Example 2.—120 lbs. of twist are required of 20s, 30s, and 60s cotton, what weight of each count will the compound twist thread contain ?

BY FORMULA XI.

1st part, Hanks ÷ Counts = Relative weight in lbs.

60	÷	60	=	1
60	÷	30	=	2
60	÷	20	=	3

60 hanks of twist weigh 6 lbs.

2nd part,

(a) $\frac{120 \times 1}{6}$ = 20 lbs. of 60s cotton.

(b) $\frac{120 \times 2}{6}$ = 40 lbs. of 30s cotton.

(c) $\frac{120 \times 3}{6}$ = 60 lbs. of 20s cotton.

Total weight = 120 lbs.

NOTE.—The relative weight for all systems of counts given under Table II. are in *direct* proportion to their counts.

When Lengths Vary. To find the respective weight of each count in a given weight of twist such as spiral, curl and all yarns in which the take-up in length of each count varies, involves a slight variation in the first part of the foregoing formula.

Generally if the two fold yarn contains fewer turns per inch than that of the single, the length of the folded material will be greater than the original length of the single; but as the twist in the two ply yarn increases, its length will gradually decrease. The actual amount of variation cannot be reduced to any simple formula. The results for different counts of yarns and twist per inch must be determined by experiment, and then tabulated for future use, *e.g.*,

One hank of 20s cotton containing 20 turns per inch is afterwards two-folded for experimental purposes, and produces the following results :—

a. 10 turns, length of ply yarn = 858 yds. per hank.
b. 15 ,, ,, ,, ,, = 838 ,, ,,
c. 20 ,, ,, ,, ,, = 830 ,, ,,
d. 25 ,, ,, ,, ,, = 800 ,, ,,

Example 1.—A corkscrew yarn is composed of 10s and 60s Botany, 5 inches of the latter being required to 3 inches of the former. What weight of each will be required to produce 100 lbs. of twist, and what number of hanks of the compound twist will weigh 1 lb. ?

By the application of formula VIII., both the

resultant counts and the relative weights of the two materials may be obtained.

NOTE.—The length of 60s is greater by $\frac{2}{3}$ than the unit length of 10s worsted.

Then,

Hanks per lb.	+	Extra length	=	Relative length expressed in hanks	÷	Counts	=	Relative weight.
60	+	($\frac{2}{3}$ of 60)	=	100	÷	60	=	$1\frac{2}{3}$ lbs.
60	+	0	=	60	÷	10	=	6 lbs.

60 hanks of twist thread weigh ... ... $7\frac{2}{3}$ lbs.

$\therefore \frac{60}{7\frac{2}{3}} = 7\frac{19}{23}$ hanks per lb. = resultant counts.

And by the latter part of formula XI., the respective weight of each thread may easily be obtained thus :—

$$\frac{\text{Required weight of twist} \times \text{relative weight of respective counts}}{\text{Sum of relative weights.}}$$

(a) $\frac{100 \times 1\frac{2}{3}}{7\frac{2}{3}} = 21\frac{17}{23}$ lbs. of 60s.

(b) $\frac{100 \times 6}{7\frac{2}{3}} = 78\frac{6}{23}$ lbs. of 10s.

Thus it will be self-evident that the combination of formula VIII. with the second part of formula XI. furnishes a ready means of solving all questions of the foregoing description. The whole is expressed in one formula for future use, thus :—

FORMULA XII.

First part, exactly as formula VIII.

Second part —

$$\frac{\text{Required weight of twist} \times \text{relative weight of respective counts}}{\text{Sum of relative weights}} = \text{weight of respective counts.}$$

N.B.—The same results might be obtained by adding to each count the extra weight to cover the additional length required to produce the unit length of twist, thus:— (See also formula VIIIb).

Hanks per lb.	÷	Counts	=	Rel. weight in lbs. when lengths are equal.	+	Extra weight to cover additional length.	
60	÷	60	=	1	+	$\frac{2}{3}$ of 1lb.	= $1\frac{2}{3}$lbs.
60	÷	10	=	6	+	0	= 6
60 hanks of twist weigh							$7\frac{2}{3}$lbs.

This latter method is slightly shorter and may be used in practice, but the former is more exhaustive and consequently more instructive.

Example 2.—An olive coloured loop yarn is composed of two threads of 8s English (32s quality) and one hard twisted thread of 12s worsted; 21 inches of the former are required to 14 inches of the latter. What weight of each will be required to produce 150 lbs. of twist, and what number of hanks per lb. will the compound thread contain?

NOTE.—The length of the 8s worsted is greater by $\frac{1}{2}$ than the unit length of the 12s.

Then by formula XII.,

Hanks per lb.	+	Extra length.	=	Relative length.	÷	Counts.	=	Relative weight.
12	+	0	=	12 hanks	÷	12	=	1 lb.
12	+	($\frac{1}{2}$ of 12)	=	18 ,,	÷	8	=	$2\frac{1}{4}$ lbs.
12	+	($\frac{1}{2}$ of 12)	=	18 ,,	÷	8	=	$2\frac{1}{4}$ lbs.
12 hanks of twist thread weigh								$5\frac{1}{2}$ lbs.

$\therefore \frac{12}{5\frac{1}{2}} = 2\frac{2}{11}$ hanks per lb. = resultant counts.

and (a) $\frac{150 \times 1}{5\frac{1}{2}} = 27\frac{3}{11}$ of 12s.

(b) $\frac{150 \times 2\frac{1}{4}}{5\frac{1}{2}} = 61\frac{4}{11}$ of 8s, first thread.

(c) $\frac{150 \times 2\frac{1}{4}}{5\frac{1}{2}} = 61\frac{4}{11}$ of 8s. second thread.

Total 150 lbs. of twist.

Example 3.—A fancy cotton twist is produced with alternate knops of white and flakes of black. The resultant yarn is composed of 1 thread of 3/42s white for core, 1 thread of 40s white, and 1 thread of 40s black. 21 inches of the core thread and 44 inches each of the white and black single yarns are required to produce 20 inches of twist. Find the resultant counts and relative weight of each sort in 150 lbs. of twist.

By formula VIIIA. (first part).

,, ,, XI. (second part).

	Relative length	÷	Counts	=	Relative weight.
Core	21	÷	14	=	1·5 lbs.
Knop	44	÷	40	=	1·1 ,,
Flake	44	÷	40	=	1·1 ,,

Unit twist = 20 hanks weigh ... 3·7 lbs.

$\therefore$ Resultant counts $= \frac{20}{3{\cdot}7} = 5{\cdot}4$

Weight of 3/42s core thread $= \frac{150 \times 1{\cdot}5}{3{\cdot}7} = 60{\cdot}8$ lbs.

,, 1/40s white $= \frac{150 \times 1{\cdot}1}{3{\cdot}7} = 44{\cdot}6$,,

,, 1/40s black $= \frac{150 \times 1{\cdot}1}{3{\cdot}7} = 44{\cdot}6$,,

Cost of Twist Yarns.

When Lengths are Equal.

Determining the cost of twist yarns is relatively easy if the previous examples and explanations have been carefully perused.

Example 1.—Find the cost per lb. of a twist, composed of 36s Botany at 2/6 per lb. and 18s worsted at 2/- per lb.

Then by the application of formula XI., 1st part.

				Relative weight in lbs,
36	÷	36	=	1
36	÷	18	=	2
36 hanks weigh				3 lbs.

Observe that the weight of 36s is 1 lb. when the weight of 18s is 2 lbs.

Consequently, 1 lb. of the former costs 2/6,
and 2 lbs. of the latter cost 4/-,
giving a total cost of 6/6 for the 3 lb. weight.

Simplified, the above would read thus :—

36 ÷ 36	=	1 lb. @ 2/6	=	2s. 6d. cost of 1 lb.
36 ÷ 18	=	2 lbs. @ 2/-	=	4s. od. cost of 2 lbs.
		3 lbs. cost		6s. 6d.

$$\therefore \frac{6s.\ 6d.}{3} = 2/2 \text{ cost per lb.}$$

which, expressed in a formula would be written thus:

FORMULA XIII.

(a) Select the highest count and divide it by itself and each of the given counts; the quotient in each case will then represent the relative weight of each thread in lbs. Then divide the selected count by the sum of these weights and the answer will equal the resultant counts. (b) Multiply the relative weight of each thread by its cost, then divide the total cost by the sum of the relative weights; the answer equals the cost per lb.

Example 2.—A twist thread is made of 19 Y. S. woollen costing 2/4 per lb. and 32s cotton costing 1/2 per lb. What is the price per lb. of the twist?

First convert cotton into woollen counts, or *vice versa*.

$$32\text{s cotton} = \frac{32 \times 840}{256} = 105 \text{ Y. S. woollen.}$$

Then proceed as explained in formula XIII.:—

105 ÷ 105 = 1 lb. @ 1/2 = 1s. 2d.
105 ÷ 19 = $5\frac{10}{19}$ lbs. @ 2/4 = 12s. 11d.

$6\frac{10}{19}$ lbs. cost 14s. 1d.

$$\therefore \frac{14\text{s. } 1\text{d.}}{6\frac{10}{19}} = 2/2 \text{ (nearly)} = \text{cost per lb.}$$

When Lengths Vary.

These, like the above, can be very readily obtained when the relative weights of each yarn are found, as explained in connection with the 1st part of formula XII. or in formula VIII.

Example 1.—A spiral twist is composed of one thread 12s Botany at 2/1 per lb., and one thread of 72s Botany at 2/4 per lb.; 11 inches of the latter are required to 8 inches of the former. Find the cost per lb.

NOTE.—The length required of 72s is greater by $\frac{3}{8}$ than the unit length of 12s Botany.

Then by formula VIII. or 1st part of XII.:—

Hanks per lb.	+	Extra length	=	Relative length	÷	Counts	=	Relative weight
72	+	($\frac{3}{8}$ of 72)	=	99	÷	72	=	$1\frac{3}{8}$
72	+	0	=	72	÷	12	=	6

72 hanks weigh ... ... $7\frac{3}{8}$ lbs.

Here we find that the weight of 72s is $1\frac{3}{8}$ lbs., when the weight of 12s is 6 lbs.

Consequently, $1\frac{3}{8}$ lbs. of 72s cost $(2/4 \times 1\frac{3}{8}) = 3/2\frac{1}{2}$
and 6 lbs. of 12s cost $(2/1 \times 6) = 12/6$

Total cost for $7\frac{3}{8}$ lbs. $= 15/8\frac{1}{2}$

$\therefore$ The cost per lb. $= \frac{15/8\frac{1}{2}}{7\frac{3}{8}} =$ 2s. $1\frac{1}{2}$d. per lb.

The same result will be more readily achieved by adding the latter part of formula XIII. to the formula used above, and for convenience, these will be combined for a new formula, which will be found applicable for problems of this class.

Formula XIV.

(1) Exactly as first part of formula XII.

(2) Multiply the relative weight of each thread by its cost, then divide the total cost by the sum of the relative weights. The answer equals the cost per lb.

Then by formula XIV.—foregoing example =

Hanks per lb.	+	Extra length	=	Rel. length	÷	Cts.	=	Rel. weight	×	Price per lb.	=	Rel. cost.
72	+	($\frac{3}{8}$ of 72)	=	99	÷	72	=	$1\frac{3}{8}$	at	2/4	=	$3/2\frac{1}{2}$
72	+	0	=	72	÷	12	=	6	at	2/1	=	12/6

72 hanks of twist thread weigh $7\frac{3}{8}$ and cost $15/8\frac{1}{2}$

$\therefore \frac{15\text{s. } 8\frac{1}{2}\text{d.}}{7\frac{3}{8}} =$ 2s. $1\frac{1}{2}$d. per lb.

Example 2.—A knop yarn is composed of one thread of 2/12s crimson-coloured mohair at 3/- per lb.; one thread of 2/20s black cotton at 1/1 per lb., and one thread of 1/20s black cotton at 1/- per lb. 39 inches mohair are required to 13 inches of each black

cotton thread. Find the number of hanks and cost per lb. and weight of each thread in 180 lbs. of twist.

Then 2/20s cotton $= \frac{10 \times 840}{560} =$ 15s worsted counts,

and 20s cotton $= \frac{20 \times 840}{560} =$ 30s worsted counts.

Then by formula XIV.:—

Hanks per lb.	+	Extra length	=	length Rel.	÷ Cts.	=	Rel. Weight	×	Price per lb.	=	Rel. cost.
30	+	(2 × 30)	=	90	÷ 6	=	15	at	3/-	=	45/-
30	+	0	=	30	÷ 30	=	1	at	1/-	=	1/-
30	+	0	=	30	÷ 15	=	2	at	1/1	=	2/2

30 hanks of twist threads = 18 lbs. and cost = 48/2

$\therefore \frac{30}{18} = 1\frac{2}{3}$ hanks per lb. = resultant counts,

and $\frac{48\text{s. } 2\text{d.}}{18} =$ 2s. 8d. per lb.

Then (1) $\frac{180 \times 15}{18} =$ 150 lbs. of mohair.

(2) $\frac{180 \times 1}{18} =$ 10 lbs. of 1/20s cotton.

(3) $\frac{180 \times 2}{18} =$ 20 lbs. of 2/20s cotton.

Example 3.—A knop twist yarn is made of one thread of 2/20s light green mohair at 3/1 per lb., one thread of 2/24s black cotton at 1/2 per lb., and one thread of 1/24s cotton at 1/1 per lb. If 27 inches of mohair and 12 inches of each cotton thread only produce 9 inches of twist, find the number of hanks and cost per lb., and weight of each kind of thread in a total weight of 160 lbs. of twist.

Then 2/24s cotton $= \frac{12 \times 840}{560} = 18$s worsted.

and 1/24s cotton $= \frac{12 \times 840}{560} = 36$s worsted.

NOTE.—The length of mohair is twice greater, and that of cotton is $\frac{1}{3}$ greater than the unit length of twist thread.

By formula XIV.:—

Hanks per lb.	+ Extra length	= Rel. length	÷ Cts.	= Rel. weight	× Price per lb.	= Cost
36	$+(2\times36)=$ 108	÷ 10	= $10\frac{4}{5}$	× 3/1		$= 33/3\frac{1}{2}$
36	$+(\frac{1}{3}\times36)=$ 48	÷ 36	= $1\frac{1}{3}$	× 1/1		$= 1/5\frac{1}{4}$
36	$+(\frac{1}{3}\times36)=$ 48	÷ 18	= $2\frac{2}{3}$	× 1/2		$= 1/1\frac{1}{4}$

36 hanks of twist weigh ... $14\frac{4}{5}$ and cost = 37/10

(a) $\frac{36}{14\frac{4}{5}} = 2\frac{16}{37}$ hanks per lb. = resultant counts.

(b) $\frac{37\text{s. } 10\text{d.}}{14\frac{4}{5}} = 2\text{s. } 6\frac{1}{2}\text{d.}$ per lb. cost of twist thread.

(c) $\frac{160 \times 10\frac{4}{5}}{14\frac{4}{5}} = 117$ lbs. weight of 2/20s mohair.

(d) $\frac{160 \times 1\frac{1}{3}}{14\frac{4}{5}} = 14{\cdot}4$ lbs. weight of 1/24s cotton.

(e) $\frac{160 \times 2\frac{2}{3}}{14\frac{4}{5}} = 28{\cdot}8$ lbs. weight of 2/24s cotton.

160·2 lbs., total.

By formula VIIIB.:—

	Highest count	÷ Counts	= Relative Wt. × Length.		
Mohair ...	36	÷ 10	= $3\frac{3}{5}$ × $\frac{27}{9}$	=	$10\frac{4}{5}$ lbs.
1/24s Cotton	36	÷ 36	= 1 × $\frac{12}{9}$	=	$1\frac{1}{3}$ lbs.
2/24s ,,	36	÷ 18	= 2 × $\frac{12}{9}$	=	$2\frac{2}{3}$ lbs.

36 hanks of twist weigh ... $14\frac{4}{5}$ lbs.

and by Formula VIIIa.:—

	Relative length.	÷	Counts.	=	Relative weight.
10s Mohair	27	÷	10	=	$2\frac{7}{10}$ lbs.
24s Cotton	12	÷	36	=	$\frac{1}{3}$ lbs.
2/24s ,, ...	12	÷	18	=	$\frac{2}{3}$ lbs.
Twist ...	9 hanks weigh ...				3·7 lbs.

$= 2\frac{16}{37}$ resultant counts.

EXERCISES.

A. **General.**

1. What will be the resultant counts in worsted of 80s cotton and 36s worsted, and what quantity will be required of each to produce 100 lbs. of twist?

Ans., $27\frac{9}{13}$; $23\frac{1}{13}$; $76\frac{12}{13}$.

2. What will be the resultant counts of two threads twisted together as follows, viz:—80s single cotton with 30s single worsted, and what quantity of each will be required to produce 100 lbs. of yarn—answer in cotton.

Ans., 16s; 20; 80.

3. 30s and 36s worsted and 40/2s silk are twisted together. Find the relative weights of each in 150 lbs., and the resultant counts.

Ans., $64\frac{2}{7}$; $53\frac{4}{7}$; $32\frac{1}{7}$; $12\frac{6}{7}$.

4. A twist thread is composed of 60s and 40s worsted and 30s cotton of respective values 32, 24 and 16 pence per lb, Find the resultant counts in worsted and cost per lb.

Ans., $15\frac{15}{23}$; $1/11\frac{7}{23}$.

5. Find the cost per lb. of two yarns twisted together composed of 36s at 3/6 and 14s at 2/6.

Ans., $2/9\frac{9}{25}$.

6. A twist thread is composed of 60/2 spun silk at 12/- and 20s skeins woollen at 2/8 per lb. Find the cost per lb.

Ans., $3/6\frac{1}{3}$.

7. A compound twist thread contains one thread of 2/80s worsted at 3/-, one of 60/2 spun silk at 16/-, and one thread of 2/60s worsted at 2/10 per lb. Find the counts, price per lb., and quantities of each in 100 lbs. of twist.

Ans., $14\frac{2}{5}$; 5/-; 36; 16; 48.

8. 16s West of England and 70/2 spun silk are twisted together. Give size of compound thread and cost per lb. when the former costs 2/6 and the latter 15/- per lb. Answer in West of England.

Ans., $14\frac{7}{20}$; 3/6.

9. A special twist thread is made up of one thread of 18s and one thread of 24s. The former costs 2/4 and the latter 2/5 per lb. 13 inches of the single yarns produce 12 inches of twist. Find the cost and hanks per lb.

Ans., $2/4\frac{1}{2}$; $9\frac{1}{2}$.

10. A fancy loop yarn is composed of 1/60s slate worsted at 2/10; 2/60s slate worsted at 3/-; 2/60s light green cotton at 2/-; 2/60s yellow cotton at 2/- per lb.; 18 inches of 1/60s and 9 inches of each cotton thread are required to every 6 inches of 2/60s worsted and compound twist thread. Find the resultant counts in worsted and price per lb.

Ans., $6\frac{2}{5}$; 2/6.

B. **Woollen and Worsted.**

1. Required the weight of 24s worsted to twist with 100 lbs of 40s worsted.

Ans., $166\frac{2}{3}$.

2. Find the resultant counts of 40s and 16s cut Hawick, and the proportion of each in 100 lbs.

Ans., $11\frac{3}{7}$; $28\frac{4}{7}$; $71\frac{3}{7}$.

3. A woollen twist yarn is made of 4s run and 12s Yorkshire Skeins, find the resultant counts and proportion of weight of each in 200 lbs. Answer in Y. S.

Ans., $8\frac{1}{9}$; $64\frac{32}{37}$; $135\frac{5}{37}$.

4. An 8-dram yarn (80 yds.) is twisted with 24s cut Gala. Find the relative weight of each sort in 60 lbs. of twist.

Ans., $39\frac{3}{23}$; $20\frac{20}{23}$.

5. 18s and 32s Continental worsted, at 7 and 7·5 francs per kilogramme, are twisted together. Find the resultant counts, Continental, price per kilogramme in francs, also counts in English worsted, and price per lb. of compound thread.

Ans., 11·52; 7·18; $10\frac{1}{5}$; 2/7 nearly.

6. What are the counts and price of one thread of 2/84s worsted at 3/6 per lb., one thread 28 skeins woollen costing 2/6 per lb. Allow 5% for take-up in worsted.

Ans., $9\frac{9}{13}$; 2/9.

7. A compound twist thread is made of 60s, 48s, and 40s worsted costing respectively 3/6, 3/4 and 2/8 per lb. Find resultant counts and proportionate weight of each in a total weight of 300 lbs., and price per lb. of compound thread.

Ans., 16s; 80; 100; 120; $3/1\frac{1}{3}$.

8. A spiral worsted twist is composed of 2/60s at 3/- and 1/8s at 2/8 per lb. 12 inches of the former are required to 8 inches of the latter. What are the number of hanks and price per lb. of the compound thread?

Ans., $5\frac{5}{7}$; $2/9\frac{1}{7}$.

9. What counts worsted is required to twist with 28 Y. S. so as to make a folded yarn equal 20 skeins? Also what proportion of each will be contained in 100 lbs. of twist?

Ans., 32s; $71\frac{3}{7}$ woollen; $28\frac{4}{7}$ lbs. worsted.

C. Cotton and Silk.

1. 50s and 70s cotton yarn are twisted together, what is the resultant twist and how much of each would be required to produce 120 lbs. of folded yarn?

Ans., $29\frac{1}{6}$; 70; 50.

2. Required the weight of 2/48s and 40s cotton in 100 lbs. of twist.

Ans., $62\frac{1}{2}$; $37\frac{1}{2}$.

3. If 36s cotton containing 20 turns per inch when two-folded produces 860, 852 and 830 yards per hank as compared with 840 in the single, the respective turns per inch in the two ply yarn being 15, 21 and 30, find the number of hanks per lb. of the cotton ply.

Ans., $18\frac{3}{7}$; $18\frac{9}{35}$; $17\frac{3}{4}$.

4. A compound cotton thread is made of 3/30s, 2/36s and 3/24s. Find resultant counts and proportion of each in 240 lbs.

Ans., $3\frac{1}{2}$; 85·6; 47·5; 106·9.

5. A cotton knop yarn is composed as follows:—1 thread of 3/36s white, for core; 1 thread of 20s white; 1 thread of 20s red, and 1 binder thread of 20s (white). The respective relative lengths of each yarn required to produce *20 inches* of fancy twist are:—21in.; 42in.; 42in. and 22in. Find the resultant number of hanks per lb., together with the % of yarn required of each sort.

Ans., 2·83 respective counts; Core, 24·8; White, 29·8; Red, 29·8; Binder, 15·6 %.

6. A fancy cotton twist yarn is composed of 1 thread of 2/30s black at 1/3; 1 thread of 3/40s white at 1/4, and 1 thread of 32s white at 1/- per lb. 10 inches of the compound twist thread contains 26 inches of the black and 28 inches of both the white yarns. Ascertain the resultant number of hanks and cost per lb. Allow 2d. per lb. for twisting.

Ans., $2\frac{2}{15}$ respective counts; 17d. (15 + 2).

7. Find the resultant counts and material cost per lb. of a twist thread composed of a 6s cotton at 10d. and 10s cotton at 11d. per lb.

Ans., $3\frac{3}{4}$; $10\frac{3}{8}$d.

E. **Linen and Jute.**

1. If 12 lbs. per spindle Jute twist yarn is composed of 7 lb. per spindle and a second thread, find the size of the latter and the relative proportions of each in 100 lbs. of twist.

Ans., 5; $58\frac{1}{3}$; $41\frac{2}{3}$.

2. A twist yarn is composed of dry spun flax 2 lbs. per spindle at 1/6 per spindle, 50s lea or line yarn at 5/- per bundle and 18s cotton at 10d. per lb. Find (1) resultant counts in lbs. per spindle and (2) cost per spindle; (3) resultant counts in Linen system; (4) cost per lb. and (5) per bundle.

Ans., 3·912; 3s. $6\frac{3}{4}$d.; 12·26s lea; 10·95d.; 14s. 11d.

3. What is the cost per lb. and per bundle of a spiral twist yarn composed of 20s linen at 10/- per bundle, and 12s cotton at 9d. per lb.; 9 inches of linen are required to 10 inches of cotton.

Ans., 10·8d.; 15/-.

4. A twist thread is composed of one thread each of the following linen yarns:—35s bleached at 9/-; 35s dyed at 9/6 and 40s boiled at 7/6 per bundle. Find the resultant counts and price per bundle of the twisted yarn.

Ans., $12\frac{4}{23}$; 26/-.

CHAPTER IV.

Buying and Selling Flaxes.

Buying and Selling of Flaxes.

The chief flax producing countries are:—Russia, Belgium, Holland, Ireland, France, Germany, and prospectively, British East Africa.

The mode of packing and basis of sale vary in each country, hence it is essential to become conversant with each respective system of weights and money values.

Irish Flaxes.

Irish flaxes are bought and sold at shillings per stone, except in some few markets, where the rate of exchange is shillings per cwt.

Foreign flaxes are usually converted from their customary rate of exchange into pounds sterling per ton.

French and Belgian Flaxes.

Flax produced in Belgium may be classed under three chief divisions:—(a) River retted; (b) Pool retted, denominated "blue flax"; and (c) Dew retted.

The Belgians adopt the same monetary standard as the French. (See Table III., page 28).

The basis of sale in most markets of Western Europe is in terms of coinage and weights which are now obsolete.

The markets or district varieties and bases of sale are tabulated in the following pages, together with their normal market equivalents and also the method of reducing the same into pounds sterling per ton.

FLEMISH FLAXES, which are frequently sold in Bruges market, are not infrequently offered at pounds sterling per ton.

WALLOON FLAXES, which are dew retted, include Tournai, Namur, Ath, Lieuse, Liege and Gembloux, and are frequently offered in the Ghent market at francs per bale of 100 kilogrammes.

FRENCH FLAXES are frequently offered in the Lille market at pounds sterling per ton or francs per 100 kilogrammes.

Conditions of Sale.

To the initial cost of the flax fibre the dealers charge factorage from 2 to 4 francs per bale for bales and baling, and commission from 1 to 4%. Usually 3 francs is charged per bale of 2 cwts. or its equivalent, which includes 1 franc for the bale and 2 francs for baling and 3% commission.

All flax, except otherwise arranged, is sold at customer's risk ex store to destination.

RUSSIAN FLAXES are chiefly collected for sale in the markets of Riga, Hoff, Pernau and Fellin. The basis of sale is expressed in pounds sterling per ton, to which initial cost of fibre must be added, the amount charged for baling and commission.

The flax from each district is represented by "base marks," and the various qualities of flax in each

TABLE G.

Belgian, Dutch and French Flaxes.

Group	Market	Basis of Sale	Markets Equivalents, etc.	Constant Number
1	*Courtrai ..	Crowns per Sac.	1 Crown = 5·8 francs; 1 Sac = 41 bottes; 72 bottes = 1 bale; 720 bottes = 1 ton.	4·04
	do. ..	Francs per 100 Kilogrs.	1 bale contains 101½ to 103 Kilogrs. Net.	
2	Ecloo ..	Francs per bale	1 bale = 72 bottes = 2 cwt.	
	do. ..	Francs per 100 Kilogrs.	1 bale contains 101½ to 103 Kilogrs. Net.	
3	Ghent ..	Stuivers per St.	1 Stuiver = 9·06 centimes.	
	Thiselt ..	do.	340 Stones = 1 ton..	
	Wella ..	do.		
4	Bruges ..	Stuivers per St.	270 Stones = 1 ton..	
5	Lokern ..	Stuivers per St.	360 Stones = 1 ton..	
	St. Nicholos	do.	360 Stones = 1 ton..	
6	Walloon ..	Sous per botte	1 Sou = 5 centimes; 700 bottes = 1 ton..	
7	Furness ..	do.	1 Sou = 5 centimes; 710 bottes = 1 ton..	
8	Dutch .. (Rotterdam)	Stuivers per St.	1 Stuiver = $\frac{1}{20}$ guild; 12 guilds = £1; 360 Stones = 1 ton..	
9	Groningen..	do.	do. do.	
10	Friesland ..	do.	320 Stones = 1 ton..	
11	Bernay ..	Francs per 110 livres	2040 livres = 1 ton..	
12	Bergues ..	Sous per botte	680 bottes per ton ..	
13	Hasnon ..	do.	720 bottes per ton ..	
14	Lille ..	Francs per 100 Kilogrs.	101½ to 103 Kilogrs. per bale	

*Courtrai Flax, though originally sold at Crowns per Sac of 41 bottes, is now usually made up into bales of 72 bottes, but the quotation is still in Crowns per Sac of 41 bottes, to which, when an artificial value of 10·18 crowns per franc is given, the product of the crowns per "sac" and this artifical value, equals francs per bale of 72 bottes = 2 cwt.

TABLE H.

Russian Flaxes.

Group	Market	Base Mark	Quality, Mark and Relative Value to the Base Mark					
1	Riga ..	K	PK	SPK	ZK	R		
	(Crown flaxes)	..	+£3	+£7	+£10	+£13/10		
2	Hoff ..	HD	PHD	FHD	SFHD	XHDX	XRX	
	(Crown flaxes)	..	+£3	+£6	+£9	+£12	+£16	
3	Pernau ..	D	LOD	OD	D	HD	R	G
	(Crown flaxes)	..	−£6	−£3	..	+£4	+£8	+£11
4	Fellin .. (Crown flaxes)	+£2	−£4	−£1	+£2	+£6	+£10	+£13

respective market are indicated by different markings as per Table H.

The state of the market determines the value of the base mark. All other qualities and markings are automatically and relatively increased or decreased, as per Table H.

Examples on Market Equivalents of Flax Prices.

Example 1.—If Courtrai flax is sold at 46 crowns per sac of 41 bottes, find its equivalent value in francs per bale of 72 bottes net.

Crowns. Frcs. per Crown. Bottes per Bale.

$$\text{Then } \frac{46 \times 5{\cdot}8 \times 72}{41 \text{ bottes per sac.}} = 468{\cdot}52 \text{ francs per bale of 72 bottes}$$

Example 2.—Find the constant number, which when multiplied by crowns per sac of 41 bottes will be equivalent to francs per bale of 72 bottes.

Assume 1 sac to cost 1 crown.

Then $\frac{1 \times 5{\cdot}8 \times 72}{41} = 10{\cdot}18$ frances per bale of 72 bottes.

∴ The product of crowns per sac of 41 bottes and the constant value of 10·18 francs will always be equal to the francs per bale of 72 bottes.

Example 3.—If Courtrai flax is bought at 48 crowns per sac of 41 bottes, find its equivalent in pounds sterling per ton net.

Crowns. Frs. per cr. Bottes per ton.

Then $\frac{48 \times 5{\cdot}80 \times 720}{41 \times 25{\cdot}22} = £193\ 16s.\ 10d.$

bottes per sac. frcs. per pound.

Example 4.—Ascertain the constant number which when multiplied by crowns per sac of 41 bottes, will express the equivalent in pounds sterling per ton.

Assume that the cost per sac to be 1 crown

Then $\frac{1 \times 5{\cdot}8}{41} \times \frac{720}{25{\cdot}22} = £4{\cdot}04$ per ton.

∴ The product of the Flemish crowns per sac of 41 bottes and the constant number 4·04 will always be equivalent to the pounds sterling per ton.

Example 5.—120 bales of Courtrai flax is offered at 100 francs per 100 kilogrammes. Find the total cost of the flax in francs and pounds sterling when each bale contains 103 kilogrammes, and 3 francs is charged for factorage, bales and baling in addition to 3% commission on the initial cost of the flax fibre.

Then initial cost of fibre $= \frac{103 \times 120 \times 100}{100} = 12360$ frcs.

and commission at 3% $= \frac{12360 \times 3}{100} = 370{\cdot}80$ frcs.

also factorage at 3 frcs. per bale = 120 × 3 = 360 frcs.

Total cost ex store in francs = 13090·80,

and total cost in money sterling $= \frac{13090 \cdot 80}{25 \cdot 22} = £519/1/3$

Example 6.—If flax is offered in Ghent market at 120 stuivers per stone, what is the equivalent price in pounds sterling per ton?

Stuivers. Centimes per stuiver. Stones per ton.

Then $\frac{120 \times 9 \cdot 06 \times 340}{100 \times 25 \cdot 22} = £146$ 8s. od. per ton.

Centimes per pound stg.

Example 7.—If a quantity of dew retted, Walloon flax is offered at 110 sous per botte, ascertain the equivalent price in pounds sterling per ton.

Then sous per botte × centimes per sou × bottes per ton.

$$\frac{110 \times 5 \times 700}{100 \times 25 \cdot 22} = £154.$$

Centimes per pound stg.

Example 8.—If Bruges flax is offered at 160 stuivers per stone, ascertain its equivalent net cost in pounds sterling per ton.

Stuivers per stone. × Centimes per stuiver. × Stones per ton.

Then $\frac{160 \times 9 \cdot 06 \times 270}{100 \times 25 \cdot 22.} = £153$ 12s. od.

Centimes in pound stg.

Example 9.—Dutch flax is bought in Rotterdam at 104 stuivers per stone, ascertain the equivalent cost in pounds sterling per ton.

Stuivers per stone × Stones per ton.

Then $\frac{104 \times 360}{1 \times 20 \times 12} = £156$ per ton.

No. of stuivers in pound stg.

EXERCISES.

1. If 30,900 kilogrammes of French flax is offered in the Lille market at 250 francs per 100 kilogrammes, calculate the number of bales required when each bale must be packed with 103 kilogrammes of flax. Also find the total cost in francs and pounds sterling when 3% is charged for commission, and 3 francs per bale for factorage and commission.

Ans., 300 bales: 80,467 francs; £3,190 12s. 2d.

2. (a) At what number of crowns per sac of 41 bottes must Courtrai flax be bought to equal £90 per ton. (b) Find the total cost of 2 tons of flax purchased at this price plus 3 francs per bale of 72 bottes for factorage and 3% commission

Ans., 22·28 crowns; £187 16s. 4d.

3. If flax is bought in Furnes costing 55 sous per botte, what is its equivalent expressed in pounds sterling.

Ans., £77 11s. 0d. per ton.

4. Find the equivalent value in pounds sterling per ton for flax bought in Bergues at 55 sous per botte.

Ans., £74 5s. 0d.

5. If a quantity of flax is purchased in Haslon market at 55 sous per botte, find its equivalent in pounds sterling per ton.

Ans., £78 13s. 0d.

6. If Friesland flax is offered at 50 stuivers per stone, find its equivalent cost in pounds sterling per ton.

Ans., £66 13s. 4d.

7. Given the following :—(a) Courtrai flax at crowns per sac ; (b) Ecloo at francs per bale ; (c) Ghent at stuivers per stone ; (d) Bruges at stuivers per stone ; (e) Lokern at stuivers per stone ; (f) Walloon at sous per botte; (g) Furnes at sous per botte; (h) Dutch (Rotterdam) at stuivers per stone; (i) Friesland at stuivers per stone ; (j) Bergues at sous per botte, and (k) Haslon at sous per botte. Reduce all the constant factors in each problem to one simple equivalent, which, when multiplied by the number of coins quoted at per basis of sale will produce an equivalent expression in pounds sterling per ton.

Ans., (a) 4·04 ; (b) 0·4 ; (c) 1·22 ; (d) 0·96; (e) 1·3 ; (f) 1·4 ; (g) 1·41 ; (h) 1·5 ; (i) $1\frac{1}{3}$; (j) 1·35 ; (k) 1·43.

8. Find the cost in francs and pounds sterling of 30 bales of Courtrai flax, which is bought at 27 crowns per sac of 41 bottes. Each bale contains 72 bottes, commission charged is 3% on the cost of the flax fibre, and 3 francs for each bale and baling.

Ans., 8690·5 francs; £344 11s. 9d.

9. Work out the value per ton in pounds sterling of the following Continental flaxes:—Courtrai at crowns; Dutch at stuivers; Bruges at stuivers; Ghent at stuivers; Eccloo at francs; Friesland at 36 stuivers.

Ans., See Table G.

10. What is the value of SPK Riga at £30 for K, of XRX Hoffs at £27 for HD, and R. Pernau at £33 for D.

Ans., See Table H.

11. Compare the values of the Dutch and Bruges stuiver and stone. What is the equivalent pence per lb. and shillings per cwt. of flax tow sold at 90 francs per 100 kilogrammes.

Ans., See Table G; 4d.; 3/6 nearly.

12. If Riga crown flax is quoted at £30 per ton K basis, what is the value of PK, SPK and ZK.

Ans., See Table H.

13. A "lot" of Irish flax weighing 17 cwts. 1 qr. 14 lbs. is invoiced at £115 1s. 6d.; baling costs 10/-; railway carriage 14/-; cartage 6/- per ton; commission 2½%; insurance 5%, and interest two months 5%. Calculate the total cost of the flax.

Ans, £120 10s. 8d.

14. If 181 cwts. 1 qr. 20 lbs. of Irish flax is weighed off and yields the fo lowing working results, calculate the yield per cwt. of line, tow and waste.

Dressed Line	Quality Sorts.	40	70	80	95	100	120
	Lbs.	55	780	4544	4922	450	13
Ends	Quality Sorts.	60	70	80			
	Lbs.	13	512	19			
Tows	Sorts.	R.	M/c 1	2	3	S.	
	Lbs.	1052	973	2179	2811	1117	

Ans., 62 33; 44·82; 4·85.

CHAPTER V.

Blending of Textile Fibres.

Yarns used in the manufacture of woven fabrics are frequently made up from wools of different qualities, values and proportions. There are also many produced by the mixture of wool and silk, cotton and wool, etc., including Angolas and other semi-woollen yarns.

In the production of flax yarns it is frequently found necessary to blend the different flax fibres as in wool and cotton. This process affords the opportunity of producing a yarn at a given price and of uniform quality or particular shade. The poor and indifferent fibres blended with the strong and more uniform are thereby capable of being spun into suitable yarn, which might otherwise only be accomplished with great difficulty.

Blends are more frequently made in tows than in line yarns.

The object here is to show how to determine the values of given mixtures and also how to produce a mixture of various materials at a fixed value.

Average Price per lb. of Mixtures of Given Quantities and Value.

The method employed in solving problems of this kind is governed by the law of averages, which is so simple that no explanation of the formula is necessary.

Formula XV.

Multiply the given quantities of each sort by its price per lb., and divide the sum of the quantities by the total cost. The result equals the price per lb. of the mixture.

Example 1.—A mixture of wool is made of 75 lbs. of black at 3/- per lb., 15 lbs. of yellow at 3/3, and 10 lbs. of lavender at 3/4½ per lb. Find the average cost per lb.

By Formula XV.

75 lbs.	×	3/-	=	225s. 0d.
15 lbs.	×	3/3	=	48s. 9d.
10 lbs.	×	3/4½	=	33s. 9d.
100 lbs.		cost		307s. 6d.

$$\therefore \quad \frac{307{\cdot}6}{100} = 3\text{s. } 0\tfrac{9}{10}\text{d. per lb.}$$

Example 2.—A mixture yarn is composed of 30 lbs. of wool at 2/3 per lb.; 20 lbs. of cotton at 9d. per lb.; 30 lbs. of shoddy at 3d. per lb.; and 20 lbs. waste at 2¼d. per lb. Find the cost per lb. of the mixture.

Then by Formula XV.

30 lbs. wool	at 2/3 per lb.	=	67s. 6d.
20 lbs. cotton	at 9d. ,,	=	15s. 0d.
30 lbs. shoddy	at 3d. ,,	=	7s. 6d.
20 lbs. waste	at 2¼d. ,,	=	3s. 9d.
			93s. 9d.

$$\therefore \quad \frac{93\text{s. } 9\text{d.}}{100} = 11\tfrac{1}{4}\text{d. per lb. of the mixture.}$$

Example 3.—Assume a mixture of dressed line is made up as follows:—500 lbs. Irish flax at 1/8 per

lb.; 250 lbs. Dutch at 1/6 per lb.; and 250 lbs. Riga at 1/- per lb. Find the average cost per lb.

Then 500 lbs. at 1/8 = 10000 pence.
250 lbs. at 1/6 = 4500 ,,
250 lbs. at 1/- = 3000 ,,

1000 lbs. cost 17500 pence.

$\therefore$ Mixture costs $\frac{17500}{1000} = 1/5\frac{1}{2}$ per lb.

Any mixes for line yarns are usually made on the Spread board and the proportion of each sort is largely governed by the number of divisions in the Spread board, *e.g.* If there are eight divisions or "leathers" the proportions might be in eighths thus: $\frac{1}{8}$, $\frac{2}{8}$, $\frac{3}{8}$, and $\frac{2}{8}$ or $\frac{1}{8}$, $\frac{3}{8}$ and $\frac{4}{8}$, etc.

Some spinners introduce a doubling or mixing gill box between the spread board and the first drawing frame, which affords a greater field for blending purposes, as the finishing gill boxes do for worsted.

Tow mixes, like blends for woollen yarn, are made by arranging the respective sorts in layers upon the store room floor in proportions which circumstances may require, until the whole of the blend has been formed into a large square or rectangular pile, *e.g.*, If $\frac{1}{3}$ of Irish (Brown), $\frac{1}{3}$ of Flemish (Blue), and $\frac{1}{3}$ of Courtrai (Light Brown), are required to form a blend, a pile of these different flaxes of equal layers would be formed. When required for use the material would be taken off the sides from top to bottom so as to assist in mixing the different fibres, which process is principally and more thoroughly performed on the carding machine preparatory to the drawing and

spinning of tow yarns, and the condensing and spinning of woollen yarns.

NOTE.—The additional cost of manipulating the above materials into yarn would, of course, have to be added to the average cost.

PROPORTION OF MIXTURE YARNS TO COST A GIVEN PRICE, AND PROPORTIONS OF EACH SORT IN A REQUIRED WEIGHT OF MIXTURE.

When two sorts of given value are mixed together to yield a fixed price the relative proportion of each material is always the same, but if three, four, or more sorts are required, the proportions may vary and still the cost of the mixture remain the same.

The solution of problems of this class will be best understood by working out the following examples upon the system most generally adopted for all mixtures, irrespective of kind.

Example 4.—A mixture is required to be made of wool which costs 1/4 per lb., and of cotton at 6d. per lb. The mixture is to cost 1/- per lb., what is the relative proportion of each sort, and what quantity of each will be wanted to produce a mixture of 100 lbs. ?

Let x = number of lbs. at 16d.

Let y = number of lbs. at 6d.

Then $16x + 6y$ = total cost of mixture in pence.

Also $12(x + y)$ = ,, ,, ,, ,, ,,

$\therefore 16x + 6y = 12(x + y) = 12x + 12y$,

and $16x - 12x = 12y - 6y$.

$$\therefore 4x = 6y \text{ or } \frac{x}{y} = \frac{6}{4}$$

The x weight is heavier than the y weight in the proportion of 6 to 4.

These weight ratios are always found to be in inverse proportion to the difference in the price of each sort, with the average cost of the mixture, thus:—

12d. $\left[\begin{matrix}16\text{d. difference } 4\\ 6\text{d. } \quad ,, \quad 6\end{matrix}\right.$ $\therefore$ $\begin{matrix}\text{Relative}\\ \text{Weights}\end{matrix}$ are $\begin{matrix}6\\4\end{matrix}$

The foregoing may be expressed in formula as used in practice, to save time.

FORMULA XVI.

Arrange the values of the different sorts so that one value shall be over the other, then place the average cost to the left of these values and connect a greater and a lesser value than the required average cost together with a bracket. Place the difference in price between the greater value and the average price opposite the lesser, and the difference in price between the lesser value and the average price opposite the greater. The results thus obtained represent the relative weight of each sort. Then the proportions of each in a required weight may be found by simple proportion, or thus:—

$$\frac{\text{Total weight} \times \text{relative weight}}{\text{Sum of relative weights}} = \text{weight of respective sorts.}$$

The above example worked out by Formula XVI. would appear thus:—

$$12 \left|\begin{matrix}16\\6\end{matrix}\right] = \begin{matrix}6 \text{ units of weight at } 1/4\\4 \text{ units of weight at 6d.}\end{matrix}$$

and respective weight of each =

$$\frac{100 \times 6}{(6+4)} = 60 \text{ lbs. at } 1/4$$

$$\frac{100 \times 4}{(6+4)} = 40 \text{ lbs. at 6d.}$$

PROOF.—6 lbs. at 1/4 = 96
4 lbs. at 6d. = 24
10 lbs. cost 120

$\therefore \frac{120}{10}$ = 1/- per lb., as required.

All examples of more than two sorts are simply an extension of this elementary principle of mixing materials of any kind to produce a given price.

Example 5.—A mixture contains wool at 1/8 per lb., waste at 2d., and cotton at 5d. per lb. What are the relative weights and proportions of each required to produce 120 lbs. of mixture at 8d. per lb. ?

First, consider the question as a compound of two questions similar to the previously worked-out example.

A As a mixture to cost 8d., materials costing 1/8 and 2d.

B As a mixture to cost 8d., materials costing 1/8 and 5d.

A 8 | 20] 6 units of weight (lbs.) at 1/8 = 10/-
2] 12 units of weight (lbs.) at 2d. = 2/-
18 units of weight cost 12/- at 8d. pr lb.

B 8 | 20] 3 units of weight (lbs.) at 1/8 = 5/-
5] 12 units of weight (lbs.) at 5d. = 5/-
15 units of weight cost 10/- at 8d. pr. lb.

Consequently it is evident that if A and B be mixed in equal proportions, or in any multiple of A or B, the resultant mixture will still cost 8d. per lb. The proportion of weight of each sort may then be found by simple rule-of-three as above. There is scarcely any limit to the variety of mixtures obtainable even at a fixed price and with the same elements of cost.

Example 5 (above) worked out by Formula XVI.:—

$$= 8 \left| \begin{matrix} 20 \\ 2 \\ 5 \end{matrix} \right| \left| \begin{matrix} 6+3 = 9 \text{ units of weight of wool} \\ 12 = 12 \text{ units of weight of waste} \\ 12 = 12 \text{ units of weight of cotton} \end{matrix} \right\} \text{Relative Weights}$$

and $\frac{120 \times 9}{33} = 32\frac{8}{11}$ lbs. of wool.

$\frac{120 \times 12}{33} = 43\frac{7}{11}$ lbs. of waste.

Ditto $= 43\frac{7}{11}$ lbs. of cotton.

120 lbs., total weight.

Example 6.—It is required to mix four materials together so as to produce 160 lbs. of mixture at 7d. per lb., viz. :—Wool at 1/6 ; cotton at 9d. ; mungo at 2d., and waste at 1½d. Find the relative weights of each so as to produce the mixture at the required price, together with the proportion of each in the total weight.

$$7 \left| \begin{matrix} 18 \\ 9 \\ 2 \\ 1\frac{1}{2} \end{matrix} \right| \left| \begin{matrix} 5 \text{ units of weight of wool} \\ 5\frac{1}{2} \text{ units of weight of cotton} \\ 11 \text{ units of weight of mungo} \\ 2 \text{ units of weight of waste} \end{matrix} \right.$$

$23\frac{1}{2}$ sum of relative weights.

Wool $\frac{160 \times 5}{23\frac{1}{2}} = 34\frac{2}{47}$ lbs.

Cotton $\frac{160 \times 5\frac{1}{2}}{23\frac{1}{2}} = 37\frac{21}{47}$ lbs.

Mungo $\frac{160 \times 11}{23\frac{1}{2}} = 74\frac{42}{47}$ lbs.

Waste $\frac{160 \times 2}{23\frac{1}{2}} = 13\frac{29}{47}$ lbs.

160 lbs., total weight.

The foregoing mixture may be produced at the same cost and in different proportions as follows :—

7	18	$5\frac{1}{2}$	units of weight of wool
	9	5	units of weight of cotton
	2	2	units of weight of mungo
	$1\frac{1}{2}$	11	units of weight of waste
		$23\frac{1}{2}$	

and $\frac{160 \times 5\frac{1}{2}}{23\frac{1}{2}} = 37\frac{21}{47}$ lbs. of wool

$\frac{160 \times 5}{23\frac{1}{2}} = 34\frac{2}{47}$ lbs. of cotton

$\frac{160 \times 2}{23\frac{1}{2}} = 13\frac{29}{47}$ lbs. of mungo

$\frac{160 \times 11}{23\frac{1}{2}} = 74\frac{42}{47}$ lbs. of waste

160 lbs., total weight.

A further illustration of the varieties of mixture producible at the same price and cost of elements is indicated below, the details of which may be worked out by the spinner or manufacturer.

7 | 18, 9, 2, $1\frac{1}{2}$ | or 7 | 18, 9, 2, $1\frac{1}{2}$ |

EXERCISES.

1. A quantity of wool at 12d. per lb. loses 45% in scouring ; a second lot at 12d. loses 25%. What quantity of each will be required to mix with clean wool at 2/6 per lb. so as to make a blend of 400 lbs. cost 2/- per lb.

Ans., 123·1, 123·1, 153·8.

2. Find the proportionate quantities required of two materials, one at 1/4 and the other at 2d., the combination to cost $10\frac{2}{5}$d.

Ans., 3 and 2.

3. Wool costing 1/8 and 1/4, cotton at 10d. and 6d.. is mixed to sell at 1/2. Give one blend that will solve this question.

Ans., 4, 8, 6, 2.

4. A "lot" of wool costs 20d. per lb. If the lot is classed into two sorts, and yields 65% of the lower quality, leaving 35% of the higher quality, which latter is estimated to be worth 4d. more per lb. than the former. What is the value of each sort?

Ans., 18·6; 22·6.

5. What would be the price of each sort if the average cost price of a 'lot' of clean wool be 2/- per lb., and respective weights are 30, 24, 20, 16 and 10 lbs. per cent., and if their values are respectively estimated at 2, 4, 4 and 6 pence per lb. above the lowest price?

Ans., 21·48; 23·48; 25·48; 25·48; 27 48d,

6. Find the cost per lb. if the following tows are blended :— 125 lbs. Roughers tow at 7d. per lb., 250 of machine tow (Nos. 1 and 2) at 8d., and 125 of re-scutched tow at 6d. per lb.

Ans., $7\frac{1}{4}$d.

7. If a good tow yarn be required by blending equal quantities of the following :—Courtrai at 10d., Irish at 9d., Dutch 8d., Pernau at $8\frac{1}{4}$d., find the average cost per lb. in a total lot of 4 cwt.

Ans., 8·8d.

8. A mixture is made in the ratio of 3 to 2 of respective values of 1/4 and 2d. Find the relative cost of mixture.

Ans., $10\frac{2}{5}$.

CHAPTER VI.

Costing of Yarns.

The cost of producing any kind of yarn can only be determined by carefully recording all the data associated with the manipulation of the raw material into yarn as set forth under the following heads and divisions.

It should, however, be noted that no two firms would arrive at exactly the same result for the same quality and count of yarn, the difference being chiefly due to local conditions, management and type and value of machinery. Consequently, the following, though based on actual practice, can only be taken as suggestive and representative.

Flax, as sold by the farmer in the scutched state, is the raw material to the spinner.

The method adopted for estimating the cost of producing linen yarns may be divided into two chief groups of stages.

(a) The first group begins with the scutched flax and terminates with the "dressed line."

This group is denominated the *Flax Department*, and includes the flax store, roughing, hackling (machining), and dressing or sorting.

(b) The second group, denominated *Preparing* and *Spinning*, includes spreading, drawing, roving, spinning, reeling, drying and bunching.

Flax Department.

Dressed Line. The solution of problems in this and the succeeding groups for any quality or average lea, involves a knowledge of the yield per cwt. of sorted or unsorted flax, together with the proportions and present values of each sort of tow and waste made, and subsequently of the relative number of machines required to precede or succeed each other, such as spreader, preparing, roving, spinning and reeling frames and their productive capacity, together with expenses incurred at every operation, including the wages paid and cost of plant, power, light, heat, and miscellaneous operatives' wages whose work cannot be located to the cost of any specific process of production.

The flax dresser sorts the hackled or dress line into different "lots," according to his estimation of their qualities and spinning properties. The usual method of distinguishing the several qualities is designated by the maximum lea number to which each respective "lot" will spin. The given lea numbers for the respective sorts are frequently only *relative* and occasionally higher than their actual spinning properties. The average cost of the dressed line may be expressed in pence per lb. or prospective bundle.

Yield Production and Costing. The average yield of dressed line of good Irish flax is about 60/65 lbs. per cwt. for fine counts. Greater yields can be obtained at the sacrifice of hackling. The average yield per cwt. of sorted Courtrai flax is about 60/65 lbs. for fine counts, 65/80 for

medium counts and 80/90 for low counts—the remainder being tow and waste, the latter of which only totals $\frac{3}{4}$ to 1 lb. per cwt.

One rougher can piece out and rough an average of about 2 cwts. per day. One hackling machine with 24 tools, attended by 4 boys, can turn off about 50 cwts. per week of 48 hours. When fitted with an automatic screwing apparatus the turn off is about 75 to 80 cwts. per week of 48 hours. If the automatic spreader be combined with the screwer the turn off is about 70 to 75 cwts. per week, but then the services of two women spreaders are dispensed with. One sorter dresses an average of 75 lbs. per day of machine hackled flax.

The average (pre-war) prices paid for the several operations are :—Roughing, Irish, 2/3, and foreign flaxes, 2/- per cwt. ; sorting, 5/1 per day ; machine boys, 8/- to 10/- per week each ; automatic screwer attendant, 12/- to 15/- per week.

The approximate cost of dressed line for spinning to an average of 60s lea is as follows :—Roughing, 2/- per cwt., scutched weight ; machining, 1/6 ; sorting, 5/1 ; and general expenses of datal employees, including office staff and management, is about 1/9. Total, 11/4 per cwt.

The current rate of wages for the foregoing operations, though subject to further fluctuations, are approximately as follows :—Roughing, Irish, 4/6 per cwt. ; roughing, baled flax, including Russian, 4/3 per cwt. ; sorters' rate at 9/3 per day ; boy attendant

for hackling machine fitted with automatic screwing apparatus, 28/- per week; the cost of machining, including management charges but exclusive of capital charges, is approximately 3/9 per cwt.

The average 1919 cost of the roughers' and sorters' equipment and a pair of hackling machines with automatic attachment is as follows :—Rougher's tool, 40/-; sorter's "ten" 30/-, and switch 65/-; a pair of hackling machines, £1,500; automatic attachment, £400. The prices for the foregoing tools in 1914 were 15/-, 12/6, 30/-, £600 and £200 respectively.

An allowance of 12½% on the capital cost of the hackling machines with accessories is required to cover the charges for wear and tear and renewals. The approximate present amount is equivalent to about 1/5 per cwt. The power required to drive a pair of hackling machines is 3 h.p., and this adds about 3d. per cwt. to the cost of the machined flax. An allowance of 7½% for interest and depreciation is necessary to cover capital charges on buildings and furnishings.

Example 1.—Assume that the market value of tows is as follows :—Roughers 60/-, machine 1 and 2, 70/-, machine 3 and 4, 80/-, and sorters' tow 90/- per cwt. respectively. Find the average price per lb. if the following proportions are made per cwt. Roughing 3 lbs., machines 1 and 2, 12 lbs., machines 3 and 4, 24 lbs. and sorting 3 lbs. Find the average price per lb.

Then 3 units of weight			at 60/-	per cwt.	=	180 0
And 12	,,	,,	at 70/-	,,	=	840 0
,, 24	,,	,,	at 80/-	,,	=	1920 0
,, 3	,,	,,	at 90/-	,,	=	270 0
42	,,	,,	Cost			3210 0

$$\therefore \text{ Price per lb.} = \frac{3210 \times 12}{42 \times 112} = 8{\cdot}18 \text{ pence.}$$

From every bale of flax several lea sorts are made.

For purposes of subsequent costing it is usual to reduce these to one common count or lea.

Example 2.—Find the average sort when the following weights and sorts of dressed line are made—8 lbs. of 40s ; 10 lbs. of 49s ; 26 lbs. of 62s and 30 lbs. of 68s lea.

The solution of this and similar problems is made on the basis of the law of averages, viz. :—Divide the sum of the products of each lea and sort by the total weight of the sorts, *e.g.*

8 lbs.	of 40s	lea =	320 leas.
12 ,,	,, 49s	,, =	588 ,,
26 ,,	,, 62s	,, =	1612 ,,
30 ,,	,, 68s	,, =	2040 ,,
76 lbs.			4560 leas.

$$\therefore \text{ Average lea No.} = \frac{4560}{76} = 60\text{s.}$$

The tow results are likewise determined as for average line, careful observations being made so as to certify that the sum of the respective weights of line, tow and waste is equivalent to the original weight of the scutched flax.

Example 3.—Find the cost per lb. of dressed line when the following particulars are known :—1 cwt. of scutched flax costing 157/6 per cwt. ; yield of dressed line 76 lbs., tow 34 lbs., the average value of which is 9d. per lb. ; allow 4/6 per cwt. for roughing, 3/11 per cwt. for machine hackling, 9/9 per cwt. for sorting and 2/- per cwt. for general expenses. Amount of waste 2 lbs. The solution of this and similar problems is as follows :—

	s.	d.
Cost of 1 cwt. of scutched flax ...	157	6
,, ,, roughing	4	6
,, ,, machine hackling ...	3	11
,, ,, sorting or dressing...	9	9
Miscellaneous expenses per cwt. ...	2	0
Total cost of production	177	8
Less value of 34 lbs. of tow at 9d. ...	25	6
Net total cost of 76 lbs. of dressed line	152	2

$\therefore$ Cost per lb. $= \frac{152/2}{76 \text{ lbs.}} = 2/-$ for the average lea of 60.

This or any other similarly obtained result may be used as a standard for approximately determining the average cost for any other lea number in the same lot of flax, which for purposes of illustration may be $\frac{1}{8}$d. per lb. per lea ; then by adding or deducting this amount for each lea number above or below the standard of 60s the average cost may be obtained for any other count or lea.

Example 4.—Assume that the cost per lb. of 60s average lea dressed line is 2/- and that the average

cost per lea is approximately $\frac{1}{8}$d. per lb., find the price of 44s average lea dressed line.

Then difference between 60s and 44s = 16s lea, and 24d. − (16 × $\frac{1}{8}$d.) = 22d. cost of 44s lea.

Example 5.—Assume 10 bales (20 cwts.) of scutched flax costs £160 per ton and yields 480, 660 and 60 lbs. of 100s, 110s and 120s dressed line and produces 55 lbs. of roughers' tow, 260 lbs. of machine 1 and 2, 515 lbs. of machine 3 and 4 and 120 lbs. of sorters' tow; "ends" 60 lbs. and waste 30 lbs. If total dressing costs 17/- per cwt. and general expenses are 1/6 per cwt., the average value of the tows is 11d. per lb. and of the ends 1/3 per lb.; find (1) the yield per cwt. of dressed line, (2) tow; (3) ends; (4) waste; (5) the average sort of line; (6) the cost per lb. and (7) per bundle.

	lbs.
Tow Roughing ..	55
,, Machine 1 and 2	260
,, ,, 3 and 4	515
,, Sorting ..	120

	£	s.	d.
Cost of scutch'd flax =	160	0	0
Dressing per ct. 17/- =	17	0	0
General Expenses per cwt. 1/6 =	1	10	0
Total Cost ..	178	10	0

Total tows = 950 lbs. at 11d. = 43 10 10

Ends .. .. 60 ,, at 1/3 = 3 15 0

Waste .. .. 30 ,, Less 47 5 10

Net cost of line = 131 4 2

Line — 100s	.. 480
,, 110s	.. 660
,, 120s	.. 60
	1200

(1) Yield per cwt. of line

$$= \frac{1200 \times 112}{2240} = 60 \text{ lbs.}$$

(2) Amount of tow per cwt.

$$= \frac{950 \times 112}{2240} = 47{\cdot}5 \text{ lbs.}$$

(3) Ends per cwt.

$$= \frac{60 \times 112}{2240} = 3 \text{ lbs.}$$

(4) Waste per cwt.

$$= \frac{30 \times 112}{2240} = 1{\cdot}5 \text{ lbs.}$$

(5) Average lea sort =

100s × 480 lbs. = 48000 leas
110s × 660 ,, = 72600 ,,
120s × 60 ,, = 7200 ,,

1200 lbs. = 127800 leas

$$= \frac{127800}{1200} = 106{\cdot}5$$

(6) Cost per lb. of dressed line

$$= \frac{131\ 4\ 2}{1200} = 26{\cdot}24\text{d.}$$

(7) Cost per bundle of D.L.

$$= \frac{26{\cdot}24 \times 200}{106{\cdot}5} = 49\tfrac{1}{4}\text{d.}$$

Example 6.—20 cwts. 1 qr. 24 lbs. of Irish flax is bought for £125 9s. 8d.; the charges for baling are 7/6 per ton; commission 2½%; carriage £1 2s. 6d.; cartage 10/2; interest at 5% and insurance at 10/-% on value of flax in mill store—4 months.

Make out an invoice for the total cost of the flax ex mill store.

Invoice.

20 cwts. 1 qr. 24 lbs. ...	=	£125	9 8
Baling	=		7 6
Commission 2½%	=	3	2 8
Total cost ex factor's store	=	£128	19 10
Railway carriage	=	1	2 6
Cartage	=		10 2
Flax store at mill ...	=	£130	12 6
5% interest 4 months ...	=	2	3 6
10/-% insurance 4 months	=		4 4
Total cost ex flax mill store	=	£133	0 4

Example 7.—The working results and values of the shorts and tows for the flax specified in Example 6 are as follows :—

Line.

Qualities	Shorts (50s to 60s)	50s	60s	70s	80s	90s	
Weight in lbs.	91 @ 1/2	1	97	520	440	116	= 1225

Tows.

Sorts	Roughers	1	2	3	4	Sorters	
Weight in lbs.	129	193	275	155	128	143	= 1023
Values per cwt.	86/-	94/-	100/-	104/-	108/-	114/-	
Waste							= 44
						Total	= 2292

The cost of roughing, hackling and sorting is 18/- per cwt. of the scutched weight. Add 2/- per cwt. for power, light and capital expenses. Find (a) the total value of the tows, less 5% insurance ; (b) the net value of the line and shorts ; (c) the cost per lb. of the dressed line, exclusive of shorts ; (d) the yield of line, shorts and tows in lbs. per cwt. ; (e) the average sort of the dressed line and (f) the relative values per lb. of the different sorts of line pro rata to the average lea number.

(a) Total value of tows

R. 129 @ 86/- = 11094
1. 193 @ 94/- = 18142
2. 275 @ 100/- = 27500
3. 155 @ 104/- = 16120
4. 128 @ 108/- = 13824
S. 143 @ 114/- = 16302
102982

∴ Total value of tows

$$= \frac{102982}{112} \times \frac{1}{20} \text{ Insurance}$$

= £45 19s. 6d.

(b) Net value of line and shorts =

Total cost of flax =	£133	0	4
Roughing, hackling and sorting =	18	18	6
Capital, power and light =	2	9	0
	£154	7	10
Less net value of tows =	45	19	6
Total cost of line and shorts =	£108	8	4

(c) Cost per lb. of dressed line

Less shorts 91 @ 1/2	£5	6	2
=	£103	2	2

$\therefore$ Cost per lb. of dressed line

$$= \frac{£103\ 2\ 2}{1225-91} = 21{\cdot}8\text{d.}$$

(d) Yield per cwt. of line and shorts, tow and waste—

$$\text{Line and shorts} = \frac{1225 \times 112}{2292} = 59{\cdot}86 \text{ lbs.}$$

$$\text{Tow} = \frac{1134 \times 112}{2292} = 50 \text{ lbs.}$$

$$\text{Waste} = \frac{44 \times 112}{2292} = 2{\cdot}14 \text{ lbs.}$$

(e) The average sort of the dressed line—

1 lb. of 50s =	50 leas	
97 lbs. of 60s =	5820	,,
520 lbs. of 70s =	36400	,,
400 lbs. of 80s =	32000	,,
116 lbs. of 90s =	10440	,,
1134 lbs. =	84710	

$\therefore$ Av. lea = $\frac{84710}{1134} = 74{\cdot}7$

(f) The relative values per lb. of the different sorts of line pro rata—

= As	74·7	:	50	:: 21·8	: 14·00d.
	,,		60	,,	: 17·51d.
	,,		70	,,	: 20·42d.
	,,		80	,,	: 23·34d.
	,,		90	,,	: 26·30d.

Cost per Bundle from Dressed Line and Tow to Yarn.

To the cost per lb. or bundle must be added the cost of spreading, preparing, roving, spinning and reeling, etc., or carding, combing, etc.

Line Yarn.

Example 1.—Assume the market price of 105s lea is 8/6 per bundle, less the usual 11%; dressed line cost 50 pence, then the amount left to cover preparing, spinning and profit may be found as follows :—

8/6 less 11% = 90·78 pence per bundle.
∴ 90·78 − 25 = 40·78 ,, ,,

Some idea of the total cost of preparing, spinning, and reeling per bundle may be formed by the following particulars of turn off and sectional costs. These will serve as bases to demonstrate the principle of solution and as examples of the variety of problems which arise in costs and production.

One spreader with two boards will turn off from 300 to 350 lbs. of Courtrai and 450 to 500 lbs. of Belgium and similar flaxes per day, and keep an average of 3 systems of preparing supplied with material ; 3 systems of drawing will turn off about 2000 lbs. per week of rove weighing an average of 200 yds. per oz. or 1620 lbs. per week of rove, weighing an average of 250 yds. per oz. and supply rove for 1800 to 2000 spindles, which will turn off 825/880 bundles per week respectively, or an average of 16 cuts per spindle per day for the 60s lea count. The 1914 average wage list per system of preparing was about 50/- to 52/6 and per

spinning room of 3000 spindles about £22 and the proportion for reeling about £10.

The proportionate cost of spreading, preparing, spinning and reeling per bundle for an average of 60s lea warp is as follows :—

	1914.	
(a) Preparing	$2\frac{1}{2}-3$	pence per bundle
(b) Spinning	$3\frac{1}{2}-4$	,,
(c) Reeling, drying and bundling	$2\frac{1}{4}-2\frac{1}{2}$	,,
(d) Mechanics, hackle setters, carpenters, etc., administration and management	$2\frac{1}{2}-3$	,,
(e) Capital charges, interest, depreciation, renewals, insurance	$3\frac{1}{2}-4\frac{1}{2}$	,,
(f) Fuel and light	$2\frac{1}{4}-2\frac{1}{2}$	,,
Spinning margin ...	$16\frac{1}{2}-19\frac{1}{2}$	,,

In 1917 the spinning margin costs increased to an average of 27-30 pence, and in 1919 to 50 pence per bundle for the same average lea number.

For most lea sorts from 18 to 20% must be added to the required number of bundles of spun yarn, as demonstrated in the following :—

Example 2.—Required the weight of dressed line to spin 500 bundles of 50s lea yarn when the loss is estimated at 20% on the reeled thread.

Then 200 cuts per bundle plus 20 cuts per 100 =
200 + (2 × 20) = 240 cuts of dressed line for each bundle,
and 240 cuts ÷ 50s lea = 4·8 lbs. per bundle.

$\therefore$ Amt. of dressed line reqd. $= 500 \times 4{\cdot}8$ lbs. $= 2400$ lbs.

The whole may be simplified and stated thus :—

$$\frac{500 \times (200 + 20 \times 2)}{50} = 2400 \text{ lbs.}$$

Example 3.—Assuming that the dressed line cost 22d. per lb. and the average cost of production to the reeled yarn is 2/6 per bundle on the net weight, and if 1220 lbs. of dressed line are required to produce 250 bundles of 50s lea warp yarn, find the total cost per lb. omitting commission and profits ; allow for 200 lbs. waste which realises 8d. per lb.

		s	d.
1220 lbs. of dressed line at 22d. per lb.	=	2236	8
250 bundles of 50s lea at 2/6 per bundle	=	625	0
Total	=	2861	8
Less 200 lbs. waste at 8d. per lb.	=	133	4
Total net cost	=	2728	4

$$\frac{\text{Then 250 bundles} \times \text{200 cuts per bundle}}{\text{50 cuts per lb.}} = 1000 \text{ lbs.}$$

and $\frac{2728 \times 4}{1000} = 2/8\frac{37}{50}$ per lb.

If the price per bundle were required, then the solution would simply be—

$$\frac{2728 \times 4}{250} = 10/11 \text{ per bundle.}$$

Example 4.—Find the selling price less 11% of 60s lea yarn, spun from dressed line valued at 26d. per lb. and wasting 18% on yarn in production. Allow a spinning margin of 36d. per bundle for production, commission and profits.

Then,

Amount of dressed line required to spin 1 bundle

$$= \frac{200 \text{ cuts} + 18\% \text{ waste}}{60 \text{ cuts}} = \frac{236}{60} = 3{\cdot}93 \text{ lbs.}$$

and cost of dressed line required to spin 1 bundle

$$= 3{\cdot}93 \times 26 = 102{\cdot}18 \text{ pence}$$

also cost of dressed line plus spinning margin per bundle

$$= 102{\cdot}18 + 36 = 138{\cdot}18 \text{ pence.}$$

$\therefore$ Selling price per bundle less 11% discount

$$= \frac{138{\cdot}18 \times 100}{89} = 13/\text{-}.$$

Tow Yarns.

Example 5.—Find the selling price less 11% which could be accepted for 40s lea, combed tow yarn—carded, prepared and spun from tow material of average value at 4d. per lb. Waste in carding 8%; combing 22% on carded sliver (4% waste + 18% noils value 2d. per lb.) Add 15% to waste in yarn production and allow a spinning margin of 28d. per bundle.

First Method.

Tow	100 lbs. at 4d.	= 400d.	
Waste	8		
Carded sliver	92 lbs. cost	= 400d.	
$\therefore$ 1 lb. costs $400 \div 92$			= 4·347
Then 100 lbs. carded sliver costs			= 434·7
Less	18 lbs. noils at 2d. lb.	36·0	
	4 lbs. waste	0·	
Then 78 lbs combed sliver			= 398·7
and 1 lb. „ „ $\frac{398{\cdot}7}{78}$			= 5·113

Weight of combed sliver required to spin 1 bundle of 40s lea

$$= \frac{200 + 15\%}{40} = 5{\cdot}75 \text{ lbs.}$$

Cost of combed sliver required to spin 1 bundle

$$= 5{\cdot}75 \times 5{\cdot}113 = 29{\cdot}39$$

including margin $= (29{\cdot}39 + 28) =$ d. $57{\cdot}39$

$\therefore$ Selling price less 11%

$$= \frac{57{\cdot}39 \times 100}{89} = 5/4\tfrac{1}{2} \text{ per bundle.}$$

Second Method.

Tow 100 lbs. − waste 8 = 92% of carded sliver.

Combed sliver % of tow

$$= \frac{92}{1} \times \frac{78 \text{ combed sliver}}{100 \text{ carded sliver}} = 71{\cdot}76 \text{ lbs.}$$

Noil % of tow

$$= \frac{18}{100} \times \frac{92}{1} \text{ C.S. \% of tow} = 16{\cdot}56 \text{ lbs.}$$

Net cost per lb. of combed sliver

$$= 400 \div (16{\cdot}56 \times 2 \text{ noils}) = 5.113\text{d.}$$

The remainder of the solution is as the latter part of the first method.

Example 6.—Find the selling price per bundle less 11% discount which could be accepted by the spinner for 25s lea tow yarn. The average cost of the tow is 5d. per lb., waste on tow in carding 20% and on yarn 16%. Allow a margin of 25d. per bundle to cover yarn production profits, etc.

First Method.

Tow − waste = carded sliver

100 − 20% = 80 lbs. = C.S. of tow.
Yarn + waste % = C.S.
100 + 16% = 116 lbs.

% C.S. of tow : % C.S. of yarn :: wt. yarn : wt. tow yarn
As 80 : 116 :: 100 : 145

Waste % of tows on yarn
= 145 − 100 = 45%.

Lbs. of tow per bundle of 25s lea

$$= \frac{\overset{\text{cuts}}{(200 + 45\%)}}{25 \text{ cuts}} = 11{\cdot}6 \text{ lbs.}$$

Net value per bundle
= 11·6 lbs. @ 5d. + 25d. margin = 83d.

Selling price less 11%
= As 89 : 100 :: 83 : 7/9¼.

Second Method.

Tow.	Total value.
100 lbs. @ 5d.	= 500d.
20 lbs. waste	
80 lbs. carded sliver	= 500d.
Net value per lb. ,, ,,	= 6·25d.

$$= \frac{\overset{\text{No. cuts}}{(200 + 16\%)}}{25 \text{ cuts}} = 9{\cdot}28 \text{ lbs.}$$

Net value of yarn per bundle
= 9·28 × 6·25 + 25d. margin = 83d.

Selling price less 11%
= As 89 : 100 :: 83 to x
= 7/9¼ per bundle.

Turn Off.

Example 1.—If 14 cuts per spindle are produced per

10 hours on 3 frames each containing 200 spindles revolving at the rate of 5000 revolutions per minute and producing 70s lea warp with 14 turns per inch, what weight is produced in 48 hours ?

$$\text{Then } \frac{14 \text{ cuts per spindle} \times 600 \text{ spindles}}{70 \text{ cuts per lb.}} = 120 \text{ lbs. per 10 hrs.}$$

$$\text{And } 120 \times 48 = 576 \text{ per week.}$$

Example 2.—If the spindles of a flax spinning frame producing 65s lea yarn with 13·9 turns per inch, revolve at the rate of 5000 turns per minute and if the turn off per spindle be 15 cuts per 10 hours, what is the actual loss per cent. in running of the spindles from all causes ?

Then calculation length of yarn spun

$$= \frac{5000 \times 60 \times 10}{13{\cdot}9 \times 36 \times 300} = 20 \text{ cuts}$$

and 20 cuts − 15 = 5 cuts, loss on 20.

or As 20 : 100 :: 5 : x or loss per cent.

$$\therefore \quad x = \frac{100 \times 5}{20} = 25\%$$

Example 3.—Assume 10 systems of drawing, turn off 6500 lbs. per week of rove weighing 200 yds. per oz. What is the wage cost per bundle of preparing for an estimated average lea of 60s line to be spun from double rove, when the total wage list for the rooms amounts to £40 12s. 6d. ?

$$\text{Then } \frac{6500 \text{ lbs.} \times (300 \text{ yds.} \times 60 \text{ leas})}{60{,}000 \text{ yds. per bundle.}} = 1950 \text{ bundles.}$$

$$\text{And } \frac{£40\ 12\text{s. } 6\text{d.}}{1950} = 5\text{d. per bundle.}$$

Example 4.—If the average turn off per spindle per

day, for an average lea of 60s is 16 cuts, what is the cost of spinning per bundle in a room which contains 3000 spindles, assuming the total wage list amounts to £40 per week of $5\frac{1}{2}$ days?

Then $\frac{3000 \text{ spindles} \times 16 \text{ cuts}}{200 \text{ cuts per bundle}} = 240$ bundles per day.

And $240 \times 5\frac{1}{2} = 1320$ bundles per week.

$\therefore$ Cost per bundle $= \frac{40 \times 20 \times 12}{1320} = 7{\cdot}28$ pence.

Weight and Draft of Rove.

The weight of flax rove is usually designated in yards per ounce or drams per 100 yards. The solution of any problem involving the weight of rove, draft and lea number, may be readily ascertained as below.

Example 1.—Required the draft for 24s lea yarn when the rove weighs 50 yards per ounce.

Then yds. per lb. of yarn required = yds. per lb. of rove × draft.
= yds. per lea × leas per lb. = weight of rove in ozs. × ozs. per lb. × draft.
$= 300 \times 24 = 50 \times 16 \times$ draft.

$\therefore$ Draft $= \frac{300 \times 24}{50 \times 16} = 9.$

The constant factors, yards per lea and ozs. per lb. may be reduced to one common factor or gauge point thus, $300 \div 16 = 18{\cdot}75$, which equals the number of yards per oz. or 1s lea.

Then $\frac{\text{Gauge point} \times \text{lea number}}{\text{Weight of rove in ozs.}} = \text{Draft.}$

$= \frac{18{\cdot}75 \times 24}{50} = 9.$

Example 2.—The weight of 100 yards of rove is 32

drams, find the amount of draft requisite to produce 16s lea yarn.

Then yds. per lb. of yarn = yds. per lb. of rove × draft.

$$= \text{yds. per lea} \times \text{leas per lb.} = \left(\frac{\text{yds. of rove}}{\text{weight in drams}} \times \frac{\text{drams per lb.}}{1}\right) \text{draft}$$

$$\therefore \text{Draft} = \frac{\text{yds. per lea} \times \text{leas per lb.} \times \text{weight of rove in drams.}}{\text{Length of rove} \times \text{drams in one lb.}}$$

$$= \text{Draft} = \frac{300 \times 16 \times 32}{100 \times 256} = 6.$$

The constant factors, yards per lea, standard length of 100 yds. and drams per lb., reduced to their lowest equivalent may be used as a gauge point, thus :—

$\frac{100 \times 256}{300} = 85{\cdot}3$ from which the following formula may be deduced :—

$$\frac{\text{Lea No. reqd.} \times \text{weight of rove in drams}}{\text{Gauge point}} = \text{draft.}$$

$$\therefore \text{Draft} = \frac{16 \times 32}{85{\cdot}3} = 6 \text{ as above.}$$

EXERCISES.

1. Given 8 cwts. of dressed line, find the number of bundles of 75s lea that would be produced if the loss of fibre on the finished yarn equals 20% ?

Ans., 280 bundles.

2. Assume it is required to spin 250 bundles of 50s lea yarn and that the amount of loss in fibre on the spun thread is 18%, find the total weight of dressed line required.

Ans., 1180 lbs.

3. A small lot of Irish flax weighing 10 cwts. 2 qrs. 13 lbs. was bought from the farmer at 8/6 per stone. After hackling it produced 630 lbs. of dressed line and 460 lbs. of tow of average value at 4½d. per lb. Calculate the average yield of dressed line, tow and waste per cwt., also the average cost of the dressed line per cwt.—the cost of hackling being reckoned at 8/6 per cwt.

Ans., 53 ; 39 ; 8%, etc.

4. The flax in question 13, page 86, when worked into tipples produced the following results :—

Line or tipples 1020 lbs.

		Tows.			
Qualities	R	M/c1	2	3 and 4	Waste
Wt. in lbs.	250	300	200	151	25
Values per cwt.	40/-	43/-	46/-	49/-	Nil

Calculate (a) the yield per cwt. of line, tow and waste ; (b) the total value and average per lb. of the tows less 5% insurance ; (c) the net cost per lb. of the tipples, including a charge of 3/- per cwt. for hackling.

Ans., (a) 58·7 ; 51·86 ; 1·47 ; (b) £16 15s. od. ; 4·4d. ; (c) 10·85d.

5. Find the spinning margin for 80s lea warp sold at 7/9 per bundle less 11% discount, cost of dressed line 1/6 wasting 16% on yarn in production.

Ans., 28·7d.

6. Ascertain the margin for spinning 40s lea warp quoted in the market at 6/9 per bundle less 11%. The average value of the dressed flax is 8½d. per lb. and the waste 20% on yarn in production.

Ans., 21·09d.

7. If the average cost per lb. of a dressed line "mix" is 9·8d. and the waste 18% on yarn in production of 50s lea warp, find the selling price less 11% discount. A margin of 20 pence per bundle is to be reckoned for spinning.

Ans., 6/2½.

8. Required the selling price per bundle less 11% for 90s lea spun from a mixture costing 15d. per lb. and wasting 17% on yarn in production and showing a spinning margin of 24d.

Ans., 5/10¾.

9. Given 70s lea weft at 4/9 per bundle. less 11%, wasting 16% on yarn in production and affording a spinning margin of 18d. Calculate the maximum price which the mixture of dressed line must cost per lb.

Ans., 9·88d.

10. Find the selling price per bundle less 11% discount which could be accepted for 30s lea combed tow, spun from material costing an average of 4·5d. per lb.; carding waste 12%; combing 18% (15% noils @ 2·25d. + 3% waste) on carded sliver. Add 16% to weight of yarn to cover waste in yarn production and allow a spinning margin of 34d. per bundle.

Ans., $7/4\frac{3}{4}$.

11. Find the spinning margin available for spinning 30s lea tow yarn. Market price 5/- per bundle less 11% discount. Value of tow 3·75d. per lb.; waste on tow in carding 18%; waste on yarn in production 18%.

Ans., 24d.

12. The flax in exercise 4, page 115, when sorted yielded as follows :—

Line.

Sort	40	50	60	70	80	} Breakings
Wt. in lbs.	63	244	372	148	25	} 852 + 56 lbs. @ 8d.

	Tows.					Waste.
Sort	R.	M/c 1	2	3 & 4	Sorters	} 1013 + 25
Wt. in lbs.	250	300	200	151	112	
Value per cwt.	40/-	43/-	46/-	49/-	59/-	

Charge for hackling 6/- per cwt. Find (a) the average lea sort; (b) the yields of line, tow and waste per cwt.; (c) the average value per lb. of tow and total value and the cost per lb. of the dressed line. Insurance 5%.

Ans., (a) 58; (b) 52·27; 58·29, 1·44; (c) 4·63, £19 11s. 0d.; (d) 12·41d.

13. (a) Find the selling price per bundle which could be accepted less 11% for 70s lea warp, prepared and spun from a bale of Courtral flax (2 cwts.) 72 bottes at 20 crowns per sac—reckoning the exchange rate at 25·34 francs per pound. An allowance of 25d. per bundle is to be made for margin on spinning and 15% on yarn for waste in production. Charge 3% for commission, 4 francs per bale for factorage, bales and baling; 3 francs per bale for freightage. Interest 4 months @ 5%, insurance 10/- per cent., hackling 8/3 per cwt. The yield of line, tows and waste is as follows :—

Line.

Sorts	60	70	80	}	Shorts
Wt. in lbs.	14	86	14	}	4 at 10¼d.

Tow.

Sorts	Ends	M/c 1	2	3	4	Sorting
Wt. in lbs.	11	22	29	17	13	12
Value per cwt.	46/-	50/-	52/-	54/-	56/-	63/-

Ascertain also (b) the yield of line, shorts, tow and waste per cwt.; (c) the total values of the tow and shorts and (d) the cost per lb. of the dressed line.

Ans., (a) 6/11½; (b) 57−2−51−1; (c) £2 6s. 10d., 3/5, 14·91d.

14. A 50s lea warp yarn contains 13 turns per inch: if spindles making 5000 revolutions per minute turn off 15·6 cuts per spindle per day, find the number of bundles per week for 40 frames, 200 spindles each.

Ans., 3432 bundles.

15. Assume the average cuts per spindle per day be 16·5 for 40s lea warp yarn, 12 turns per inch; find the number of bundles for 8000 spindles per week for a 55 warp yarn with 13·1 turns per inch.

Ans., 561·7 bundles

16. If a spindle revolves at 4800 per minute and puts 13 turns per inch into the yarn and assuming the turn off per spindle is 15·5 cuts per day of 10 hrs., what is the actual loss per cent. for stoppages of all kinds?

Ans., 24·4.

17. If 1 spindle produces 16 cuts per day, how many bundles will 12000 spindles produce per week (5½ days).

Ans., 5280.

18. (a) What yards per ounce rove would spin 25s tow on spinning draft of 7·5? (b) Find the spinning draft for double rove, 160 and 180 yards per ounce to make 40s lea.

Ans., (a) 62½ ozs. (b) 9⅜ and 8⅓.

CHAPTER VII.

Weight and Cost of Warp and Weft Yarns in Commercial Form.

Warp and weft yarns, prepared by the spinner for the manufacturer, are usually delivered for warp—on the warp beam, in the ball or chain, on bobbins or cheeses; and for weft—on spools, pirns, tubes, cops or in hank, for the woollen, worsted and cotton trades. In the linen trade, the yarn, both for warp and weft, is usually bought and sold in the bundle. But in whatever form the yarn may be despatched or received and subsequently prepared for weaving, there are necessarily a few calculations involved.

Example 1.—Assume a manufacturer orders 4 warps, 6-cut of 2/56s Botany, each 450 yards long, and containing 5760 ends. What is the calculation weight?

Then 4 warps × 450 × 5760 ends = total len. in yds., and 560 yards per hank × 28 hanks per lb. = the number of yards of 2/56s Botany per lb.

$$\therefore \frac{\text{Total length of warp in yds.}}{\text{Yds. per lb. of given counts}} = \text{weight of warps.}$$

$$\text{Thus, } \frac{4 \times 450 \times 5760}{560 \times 28} = 661\tfrac{1}{4} \text{ lbs.}$$

No additional formula is necessary since formula I. may be made to apply, thus:—

Let x = the weight of the 4 warps in lbs., then by formula I.,

$$\frac{\text{Total length in yards}}{\text{Weight in lbs.} \times \text{yards in hank}} = \text{counts.}$$

Substitute x for weight in lbs., thus :—

$$\frac{4 \times 450 \times 5760}{x \times 560} = 28 \text{ counts.}$$

$$\therefore x = \frac{4 \times 450 \times 5760}{28 \times 560} = 661\tfrac{1}{4} \text{ lbs.}$$

Example 2.—If each warp in example 1 actually weighed 10 lbs. less than the calculation weight, find the actual counts, assuming the length and number of ends agree with order.

Then calculation weight of one warp $= \frac{661\frac{1}{4}}{4} = 165\frac{1}{4}$

and actual weight of each $= 165\frac{1}{4} - 10 = 155\frac{1}{4}$ lbs.

Then, since counts of yarn are in inverse ratio of their weights (see chapter 2, page 40), and $165\frac{1}{4}$ lbs. represent the weight of 2/56s Botany,

$\therefore 155\frac{1}{4} : 165\frac{1}{4} :: 28 : x$ where x equals the counts of the lighter weight.

$$\therefore x = \frac{28 \times 165\frac{1}{4}}{155\frac{1}{4}} = 29{\cdot}8, \text{ or about 2/60s.}$$

Example 3.—Assume 100 gross of 2/32s cotton in hank is ordered, what is the calculation weight and total cost at 1/6 per lb. ?

Then 1 gross = 144 hanks. And 100 × 144 equals total number of hanks. Also the number of hanks of 2/32s in 1 lb. = 16.

$$\therefore \frac{100 \times 144}{16} = 900 \text{ lbs. calculation weight.}$$

$$\text{And total cost} = \frac{900 \times 3}{2 \times 20} = £67\ 10\text{s.}$$

Example 4.—A bundle which contains 1 gross of hanks of twofold worsted yarn weighs 12 lbs., what are the counts ?

Then, $\frac{144 \text{ hanks}}{12 \text{ lbs.}} = 12$ hanks per lb.

And, since the yarn is twofold, the counts are consequently equal to 2/24s worsted.

Boiled, Bleached, Sized and Dyed Yarns.

Flax and cotton yarns are frequently subjected to boiling, bleaching, sizing and dyeing processes, all of which influence the weight of the yarn, but the yarn number represents its count for the spun thread of standard condition.

The amount of loss on flax yarns is chiefly due to the decomposition of foreign matter such as gum, woody substances and dirt.

The following table gives approximately the loss for the respective processes :—

1.	Scoured	Loss 4 to 6 per cent.
2.	Boiled, once	,, 10—17 ,, ,,
3.	,, twice... ...	,, 18—22 ,, ,,
4.	$\frac{1}{4}$ Bleached (creamed)	,, 8—10 ,, ,,
5.	$\frac{1}{2}$,, ,, ...	,, 12—15 ,, ,,
6.	$\frac{3}{4}$,, ...	,, 15—20 ,, ,,
7.	Fully Bleached ...	,, 20—27 ,, ,,

Boiled yarn is chiefly used in the finer linens including damasks and table covers, because it is cleaner and relatively stronger than the natural grey, or green yarn ; it admits of closer setting, the manufacture of a better cloth and is easier to bleach.

The increase in weight, due to size or dressing, added for the purpose of strengthening the warp, varies from 8 to 10%, but if sized for 'weighting' only, the increase may be anything from 25% upwards.

Example 5.—A parcel of dry spun yarn weighs 450 lbs. after bleaching, the loss in weight being 20% on the spun yarn; what number of spindles of 3 lb. yarn is there?

Then original weight $= \frac{450 \times 100}{80} = \frac{2250}{4} = 562\frac{1}{2}$

$\therefore \frac{562\frac{1}{2}}{3} = 187\frac{1}{2}$ spindles.

Example 6.—Assume a half bleached cotton yarn loses 10% on the natural weight. If 54 yards weigh 1 dram, what is the count of the spun cotton thread?

Then $\frac{1 \text{ dram} \times 100}{90} = \frac{10}{9}$ original weight in drams.

And $\frac{54 \text{ yds.}}{\frac{10}{9} \text{ drams}} = \frac{54 \times 9}{10}$ = yards per dram.

Also $\frac{54 \times 9}{10} \times \frac{256 \text{ drams in 1 lb.}}{840 \text{ yds. per hank}} = 14{\cdot}8$ hanks per lb.

The whole may be simplified and stated as a fraction, thus:—

$$\frac{54 \times 90}{1 \times 100} \times \frac{256}{840} = 14{\cdot}8 \text{ hanks per lb.}$$

Example 7.—A flax or cotton warp weighing 80 lbs. is increased 5% during the process of sizing, what is the actual weight of the sized warp?

Since the increase is 5 lbs. on every 100, the weight of 80 lbs. of warp will be *pro rata* thus:—

$$\frac{80}{1} \times \frac{(100 + 5)}{100} = \frac{80 \times 105}{100} \times 84 \text{ lbs.}$$

Example 8.—If a sized warp weighs 130 lbs. and contains $7\frac{1}{2}\%$ of size what was the original weight ?

Since each original 100 lbs. was increased to $107\frac{1}{2}$ lbs., the weight of the warp will be *pro rata* thus :—

As $107\frac{1}{2}$: 100 :: 130 : x.

Where x = the original weight of warp

$$= \frac{130 \times 200}{215} = 120\frac{40}{43} \text{ lbs.}$$

Yarn Contract Problems.

Example 9.—A manufacturer places a contract for the delivery of 20,000 lbs. of worsted yarn in warp or weft within 6 months from date of contract. During the first 3 months he gives particulars for and receives 50 warps, each 2800 ends and 350 yards long of 2/56s ; 30 warps, each 1700 ends and 320 yards long of 2/40s ; 350 gross of 1/28s ; 1500 lbs. of 1/36s ; 500 lbs. of 1/18s ; and 12 skeps of 1/20s with an average net weight of 75 lbs. What weight has still to be delivered to complete the original contract ?

By formula I.,

(1) Weight of warps of 2/56s $= \frac{50 \text{ warps} \times 2800 \text{ ends} \times 350 \text{ yds.}}{560 (\text{yds. per hank}) \times 28 (\text{counts})} = 3125$ lbs.

(2) Weight of warps of 2/40s $= \frac{30 \times 1700 \times 320}{560 \times 20} = 1457\frac{1}{7}$ lbs.

(3) $\frac{350 \text{ gross} \times 144 (\text{hanks per gross})}{28 (\text{hanks per lb.})} = 1800$ lbs.

$6382\frac{1}{7}$ lbs.

of	1/36s	1500 lbs.
of	1/18s	500 lbs.
of	1/20s (in 12 skeps = 75 × 12) ..	900 lbs.

$9282\frac{1}{7}$ lbs.

∴ 20,000 lbs., amount of contract.
9,282$\frac{1}{7}$ lbs., delivered at end of 3 months.

10,717$\frac{6}{7}$ lbs., quantity awaiting particulars to complete contract.

Example 10.—A manufacturer makes a contract with a spinner for the delivery within six months of 13,500 lbs. of yarn prepared from 70s Botany top, to be delivered at the following prices:—1/16s and all counts below, at 2/1 : 1/17s to 1/24s, at 2/1$\frac{1}{2}$; 1/25s to 1/36s, at 2/2 per lb. ; 2/36s to 2/24s, at 2/3 ; 2/40s to 2/48s, at 2/3$\frac{1}{2}$ per lb. If during the specified time he received the complete delivery of the above weight to the following particulars, find the weight of each sort delivered and the total amount to be paid by the manufacturer ; also his gain or loss as compared with purchases made at the current prices as given below :—

30 warps 5760 ends 450 yds. of 2/48s	current price	2/4
25 ,, 3400 ,, 350 ,, 2/36s	,,	2/3$\frac{1}{2}$
10 skeps of 1/30s weft, net weight 800 lbs.	,,	2/3
300 gross of 2/30s in hanks	,,	2/4
9 skeps of 1/16s weft, net weight 750 lbs.	,,	2/0$\frac{1}{2}$
332$\frac{3}{4}$ lbs. in hank of 2/24s	,,	2/3

By formula I.,

$$\frac{\text{Total length in yards}}{\text{Yards per hank} \times \text{weight in lbs.}} = \text{counts.}$$

$$\therefore \frac{\text{Total length}}{\text{Yards per hank} \times \text{counts}} = \text{weight in lbs.}$$

		£	s	d.
(1) Of 2/48s warp	$\frac{30 \times 5760 \times 450}{560 \times 24} = 5785\frac{3}{4}$ lbs. at 2/3$\frac{1}{2}$ =	662	19	0

Gain on contract price at $\frac{1}{2}$d., £12 1 0$\frac{3}{4}$

(2) Of 2/36s warp $\frac{25 \times 3400 \times 350}{560 \times 18} = 2951\frac{1}{2}$ lbs. at 2/3 = 332 0 10½

Gain on contract price at ½d., £6 2 11½

(3) Of 1/30s weft — Net weight = 800 lbs. at 2/2 = 86 13 4

Gain on contract price at 1d., £3 6 8

(4) Of 2/30s in hank — $\frac{\text{No. of gross} \times \text{hanks per gross}}{\text{Hanks per lb.}} = \text{weight.}$

$\therefore \frac{300 \times 144}{15}$ = 2880 lbs. at 2/3 = 324 0 0

Gain on contract price at 1d., £12 0 0

(5) Of 1/16s weft — Net weight = 750 lbs. at 2/1 = 78 2 6

Loss on contract price at ½d., £1 11 3

(6) Of 2/24s in hank — Net weight = 332¾ lbs. at 2/3 = 37 8 8¼

Total weight = 13,500 lbs.

Total cost £1521 4 4¾

Total gain on contract price .. £33 10 8¼

Loss £1 11 3

Net gain £31 19 5¼

Testing Yarns for Counts.

It is frequently necessary to test the yarn for counts, and this may be accomplished in several ways, notably by weighing a few yards of yarn against some standard weight as is explained below, or by measuring a whole hank and weighing it against the standard weights, which represent fractional parts of a lb.

The explanations given herewith are confined to worsted, but the same principle of reasoning applies to any other system.

In 1 lb. avoirdupois there are 7000 grains. Also, in 1 hank of worsted there are 560 yards.

Then $\frac{7000 \text{ grains}}{560 \text{ (yds. in hank)}}$ = 12·5 grains the weight of 1 yard of 1s worsted.

Therefore, if 1 yard of yarn weighs $12\frac{1}{2}$ grains, the counts are 1s; or, if 2, 3, or 4 yards weigh $12\frac{1}{2}$ grains, the counts are 2s, 3s, or 4s respectively; or the number of yards of yarn which weighs $12\frac{1}{2}$ grains equals the counts in worsted.

In the worsted trade a small weight (lettered Y) is made to weigh exactly $12\frac{1}{2}$ grains, against which, a number of yards of yarn as near the number of counts as can be approximately estimated is reeled and weighed; hence, if 20 yds. are equal in weight to the yarn weight, the counts are therefore 20s. If 20s yarn is invoiced, and only 19 yards are sufficient to balance the Y weight, it is evident that the counts are too heavy, being 19s instead of 20s. When the manufacturer wishes to determine the counts of yarn in a given cloth from which he can obtain only a few inches of yarn at the most, he must then weigh this quantity as exactly as possible in grains—say, to the hundredth part of a grain.

Example 11.—Supposing 9 threads were obtainable, each 4 inches long (1 yard), and these weigh 1 grain, then the counts of this yarn would be $12\frac{1}{2}$s, because $12\frac{1}{2}$ yards would be required to weigh $12\frac{1}{2}$ grains.

Example 12.—If 60 inches of worsted yarn weigh 1·2 grains, what are the counts?

The number of yards required to weigh $12\frac{1}{2}$ grains can readily be obtained by simple proportion, and these equal the counts, thus:—

As 1·2 : 12·5 :: $\frac{60}{36}$ yards : x yards.

$= \frac{60 \times 12{\cdot}5}{36 \times 1{\cdot}2} = 17\frac{1}{3}\frac{3}{6}$ counts.
where x = the counts in worsted.

Similarly $\frac{7000 \text{ grains per lb.}}{840 \text{ yds. per hank of cotton}} = 8\frac{1}{3}$ grains for 1 yd. of 1s cotton.

And consequently the number of yards of cotton which weighs $8\frac{1}{3}$ grains = the counts.

Also for linen yarns $\frac{7000 \text{ grains per lb.}}{300 \text{ yds per lea.}} = 23\frac{1}{3}$.

∴ The number of yards which weighs $23\frac{1}{3}$ grains = No. of leas or counts.

The three foregoing examples together with the following which have been similarly deduced are tabulated for future and ready reference.

1. Worsted The No of yds. which weighs $12\frac{1}{2}$ or 12·5 grains = counts.
2. Cotton ,, $8\frac{1}{3}$,, 8·3 ,, = ,,
3. Linen ,, ,, $23\frac{1}{3}$,, 23·3 ,, = ,,
4. Woollen (Y.S.) ,, ,, $27\frac{1}{3}\frac{1}{2}$,, 27·34 ,, = ,,
5. ,, (Galashiels) ,, ,, 35 ,, = ,,
6. ,, (W. of England) ,, ,, $21\frac{7}{8}$,, 21·875 ,, = ,,
7. ,, American Run ,, ,, $4\frac{3}{8}$,, 4·375 ,, = ,,
8. ,, ,, Cut ,, ,, $23\frac{1}{3}$,, 23·3 ,, = ,,
9. Continental Worsted. The number of
   (a) Metres which weigh 1 gramme or 15·432 grains = Metric counts.
   (b) Yards ,, 14·1 ,, = ,,
10. Continental Cotton. The number of
   (a) Metres which weigh ½ gramme or 7·716 grains = Metric counts.
   (b) Yards ,, 7·05 ,, = ,,
11. Jute, tows, etc. Length in yards, divided into twice its weight in grains = lbs. per spindle approximately or the weight of 3 cuts in ounces = lbs. per spindle.

When it is possible for the spinner or manufacturer to reel a sufficient length of yarn as will represent one hank, or to extract a complete hank or lea from the bundle, the counts of the materials may be determined with greater accuracy.

Then, since the number of hanks which weighs 1 lb. avoirdupois represents the counts, it is evident that the

weight of 1 hank of 10s is $\frac{1}{10}$ of 1 lb.; of 16s, it is $\frac{1}{16}$ of 1 lb.; of 20s, $\frac{1}{20}$ of 1 lb.; of 28s, $\frac{1}{28}$ of 1 lb.; and similarly with other counts. Consequently, for greater convenience and despatch, small brass weights are made $\frac{1}{16}$, $\frac{1}{17}$, $\frac{1}{18}$, etc., parts of a lb., each weight being numbered 16, 17, 18, etc., according to the fractional part of 1 lb. that it weighs.

Against these weights the hank is compared for weight, and so, if the hank is equal in weight to the 12, 16, 20, 24, or 28 number, the counts of the material coincide with the weight number.

There is a simple invention called a hank quadrant, which is sometimes used for the above purpose. Without discussing its merits or demerits, suffice it to say, that it consists chiefly of a quadrant ($\frac{1}{4}$ circle) graduated and numbered to represent different parts of 1 lb., say from $\frac{1}{16}$ to $\frac{1}{100}$. A simple lever which contains a pointer at one end and a scale pan at the other is delicately adjusted so that if a hank is placed on the scale pan the number on the quadrant which the pointer is immediately over represents the fractional part of 1 lb. which the hank weighs, and therefore the counts.

Testing Cotton Counts—Modified Length of Hank.

The reel for testing cotton is $1\frac{1}{2}$ yds. in circumference, the same as the swift used for reeling cotton. Instead however of reeling from 7 cops and making the usual 80 revolutions which would then equal one complete hank (as is the case in the worsted trade) it is customary to reel from 4 cops and make the same

number of revolutions, viz. : 80, which produces (120 × 4) = 480 yards or 4 leas.

In cotton there are 7 leas of 120 yards each in 1 hank.

The weight of the 4 leas in grains divided into 4000 grains equals the counts of the yarn.

NOTE.—Since there are 7000 grains in 1 lb. and that if 1 hank (7 leas) weighs 70 grains, it follows that if this weight be divided into the number of grains in 1 lb. the quotient will represent the number of hanks in 1 lb., or the weight in grains of 1, 2, 3 or 4 leas respectively, divided into 1000, 2000, 3000 or 4000 = the counts.

$$\text{Thus } \frac{\text{7000 grains in 1 lb.}}{\text{70 grs.} \times \text{weight of 1 hank}} = \text{100 hanks per lb.}$$

It will also be evident that 4 leas represent $\frac{4}{7}$ of 1 hank and 4000 grains are equal to $\frac{4}{7}$ of 1 lb., therefore, if 7 leas weigh 70 grains, 4 leas will weigh 40 grains, and if this weight be divided into 4000 grains, the result will be the same, thus :—

$$\frac{\text{4000 grs., grains in } \frac{4}{7} \text{ of 1 lb.}}{\text{40 grs., weight of 4 leas.}} = \text{100 hanks per lb.}$$

from which the usual formula is deduced, viz. :—

Formula for testing cotton counts—

$$\frac{\text{4000 grains}}{\text{Weight in grains of 4 leas}} = \text{cotton counts.}$$

In a similar way it can be shown that if only 1, 2 or 3 cops are available the weight in grains of 1, 2 or 3 leas divided into 1000, 2000 or 3000 grains respectively will equal the cotton counts, *e.g.*

Example 13.—Assume 1 lea of cotton weft weighs 12½ grs., what are the counts ?

Then $\frac{1000}{12\frac{1}{2}} = \frac{1000 \times 2}{1 \times 35} = 80s$ cotton.

Example 14.—The weight of 2 leas of cotton is 50 grains, find the counts.

Then $\frac{2000}{50} = 40s$ cotton.

EXERCISES.

General.

1. If 25 yards of yarn weigh 15 grains, what are the counts in worsted, cotton, linen and American cut yarn?

Ans., $20\frac{5}{6}$; $13\frac{8}{9}$; $38\frac{8}{9}$; $38\frac{8}{9}$.

2. What is the weight in grains of 1 yard of 1s cut Hawick; Run (American); linen, West of England and cotton?

Ans., 37·9; 4·375; 23·3; 21·875; 8·3.

3. If 10 warps each 560 yards long contain 3300 ends and weigh 110 lbs. net, express the counts in worsted, cotton and linen.

Ans., 30, 20, 56.

Woollen and Worsted.

4. A 10 lb. bundle of 2/36s worsted is ordered, but when grossed and weighed it is found to weigh only $9\frac{1}{4}$ lbs. What are the actual counts of yarn, assuming that there are no hanks missing from the bundle?

Ans., 2/39.

5, Find the cost of 5 gross of hanks of 40s worsted, at 2/6 per lb.

Ans, 45/-.

5. 20 yards of woollen yarn weigh 28 grains. What are the cuts, Galashiels?

Ans., 25.

7. 8 warps, each 420 yards long of 2/36s Botany, and containing 6960 ends, cost 2/9 per lb. What is the calculation weight and total cost?

Ans., 2320; £319.

8. If 1 of the warps in question 7, only weighs 280 lbs., and if the counts of yarn and ends agree with order, what is the length?

Ans., $405\frac{1}{2}$.

9. 80 yards of woollen yarn are reeled, and weigh $7\frac{1}{2}$ drams. What are the counts, Y. S.?

Ans., $10\frac{2}{3}$.

10. A worsted yarn is invoiced as 20s, but on reeling 20 yards the same only weighs 11·8 grains. What are the actual counts?

Ans., 21·2.

11. A merchant places an order for 15,000 lbs. of yarn, and supplies particulars for a 1000, 500, and 150 gross of 40s, 30s and 2/24s respectively, and 30 warps 2/24s worsted, containing 1200 ends and 280 yards long. What weight of the original order remains to be executed? *Ans.*, 5700.

12. A three months' contract is made between a spinner and manufacturer for the delivery of 15,000 lbs. weight of worsted warp and weft, at the following rates:—

All counts up to 1/24s, at 2/6; 1/25s to 1/36s, at 2/7; 2/24s to 2/36s, at 2/8. All counts above 2/36s and up to 2/48s, at 2/9 per lb. All above 2/48s to be 2/10 per lb.

During the first two months of contract, the following warps and wefts are delivered when current prices are as detailed below:—

15 warps, 3400 ends, 300 yards of 2/24s ..	current rate,	2/9
12 warps, 4500 ends, 240 yards of 2/48s ..	,,	$2/10\frac{1}{2}$
25 skeps of 1/12s weft of total weight 2050 lbs.	,,	$2/7\frac{1}{2}$
50 gross in hanks of 2/36s	,,	2/9
10 skeps of 1/30s weft of total weight 850 lbs.	,,	$2/7\frac{1}{2}$
10 warps, 5760 ends, 450 yards of 2/44s ..	,,	2/8
130 gross of hanks of 2/24s	,,	2/7

What weight yet remains to be delivered, and what is the manufacturer's gain or loss on the goods already received by him?

Ans., $4795\frac{1}{3}$; £16 9s. 11d. gain, net.

Cotton and Silk.

13. A warp contains 3500 ends, 1000 yards long and weighs $228\frac{1}{4}$ lbs. gross; find the counts for the yarn. *Ans.*, 20.

14. An 80/2 spun silk warp, 500 yards long contains 10500 ends. Find the weight.

Ans., 156¼ lbs.

15. An invoiced 25 twist cotton warp weighs 50 lbs., contains 2200 ends and is 500 yards long. Assuming the ends and counts are proved to be correct, what is the actual length and what should the calculation weight of the invoiced warp be?

Ans., 477¾; 52·4.

16. A hank of cotton measuring 820 yards indicates on the quadrant $\frac{1}{18}$ part of 1 lb. What are the actual counts?

Ans., 17⅞

17. 120 gross of 2/60s cotton cost 1/10 per lb. Find the total weight and cost.

Ans., 576; £52 16s. 0d.

18. Find the weight in grains of 1 lea of 40s, 2 leas of 60s, 3 leas of 75s and 4 leas of 90s cotton weft.

Ans., 25; 33·3̇; 40; 44·4̇.

19 If 2 leas of cotton weigh 71·3 grains and 4 leas weigh 32 grains, what are the counts?

Ans., 28; 125

20. If 4 leas of cotton weigh 50 grains, 3 leas 60 grains, 2 leas 40 grains and 1 lea 75 grains, what are the counts?

Ans., 80, 50, 50, 13.

21. (a) A 40s twist cotton warp with 2000 ends and 150 yds. is increased 5% by sizing; what is its actual weight?
(b) A cotton warp, 1800 ends, 770 yds. long weighs 45 lbs. and is estimated to contain 6% of size. What is the twist or count of the spun warp?

Ans., (a) 9⅜ lbs.; (b) 38·86 counts.

22. Ascertain the net weight of a warp containing 1600 ends, 420 yds. long and made from 8s cotton, assuming that the warp is decreased 10% by bleaching and gains 10% in the subsequent sizing process.

Ans., 99.

Linen, Hemp and Jute.

23. $7\frac{1}{2}$ yards of a 3-fold tow carpet weft weigh 25 grains. What are the lea counts and lbs. per spindle ?

Ans., 7s lea or $6\frac{6}{7}$ spindles.

24. If 30 yards of jute weigh 2 drams. What is the number of lbs. per spindle ?

Ans., $3\frac{3}{4}$.

25. How many bundles of yarn would be required for a warp 1200 yds. long with 1600 ends ?

Ans., 32.

26. Find the lbs. per spindle of the following :—

(a) 6 yds. of dry spun flax weighing 15 grains ;

(b) 3 cuts of jute yarns weighing 6 ozs.

(c) 1 cut of hemp weighing $1\frac{1}{3}$ ozs.

Ans., $5\frac{1}{7}$; 6; 4.

27. If 16 yds. of a boiled flax yarn weigh 6 grains and the loss in weight due to boiling is 6%, what is the size or lea of the spun yarn ?

Ans., 58·5.

28. A 600 lb. lot of fully bleached 16s lea spun flax yarn has lost $22\frac{1}{2}$% on the spun thread. Find the number of bundles, cuts, and yards.

Ans., 61 bundles, 187 cuts, 29 yds.

29. If 8 bundles of 35s lea lose 15% when boiled, ascertain (*a*) the grey weight, and (*b*) the boiled weight in lbs.; also (*c*) the boiled weight in grains of 30 yds.

Ans., $45\frac{5}{7}$; $38\frac{6}{7}$ lbs.; 17 grs.

30. (a) A bundle of 30s lea loses $12\frac{1}{2}$% when boiled. Find the weight in grains of 50 yards of the boiled yarn.

(b) If a bundle of yarn weighs 8 lbs., and is estimated to have lost 10% in boiling, find the lea number for the spun yarn.

Ans., (a) 34; (b) $22\frac{1}{2}$.

31. State the quantity of yarn in spindles, also in bundles, hanks, and cuts, in a warp 500 yards long with 2,600 ends.

Ans., $90\frac{5}{8}$; 21; 11; 1·8.

CHAPTER VIII.

Winding, Warping and Beaming Problems.

The calculations involved in this group of subjects are numerous and varied ; they include the determination of the quantities, weight and cost of yarns, and these factors are modified by the productive capacity of the machines, ability of employees, quality of material and rate of payment.

Warp Winding.

Example 1.—The calculated surface speed of a warp winding drum is 120 yds. per minute and the effective turn off is 70%. Assuming a winder is allotted a share of 18 drums and that she is paid at the rate of 1/6 per 100 hanks of 3,600 yds. each, ascertain (a) the number of hanks which she can wind in a week of 48 hours ; (b) the amount she would receive in wages.

(a) No. of hanks wound per week =

$$\frac{\text{Effective turn off per min. per drum}}{\text{yds. per hank.}} \times \frac{\text{No. of drums} \times \text{Time}}{}$$

$$= \frac{120 \times 70}{100} \times \frac{18}{1} \times \frac{60 \times 48}{1} \times \frac{1}{3600} = 1209.$$

(b) Amount received in wages =

$$\frac{\text{No. of hanks wound}}{\text{No. of hanks basis}} \times \text{rate of payment}$$

$$= \frac{1209}{100} \times \frac{18}{12} = 18/1\tfrac{1}{2}.$$

Example 2.—If a cotton winder earns 21/- per week, being 18d. per bundle of 10lbs. of 40s ; 1/2 for 32s and

10½d. for 26s twist and she winds 50 lbs. of 40s and 56 lbs. of 32s what quantity does she wind of 26s and what amount does she receive for winding each sort ?

		pence	s.	d.
Then, Cost of 40s	$= \frac{50 \text{ lbs.}}{1} @ \frac{18\text{d.}}{10 \text{ lbs.}}$	$= 90$	$= 7$	6
Do. 32s	$= \frac{56}{1} \times \frac{14}{10}$	$= 78{\cdot}4$	$= 6$	$6{\cdot}4$
Amount paid for 40s and 32s		$= 168{\cdot}4$	$= 14$	$0{\cdot}4$
∴ Amount paid for 26s	$= 21/- - 14/0{\cdot}4$		$= 6$	$11{\cdot}6$

@ Weight wound of 26s twist =

$$\frac{83{\cdot}6\text{d.}}{10{\cdot}5\text{d.}} \times \frac{10 \text{ lbs.}}{1} = 79{\cdot}62 \text{ lbs.}$$

Weft Winding.

The rate of payment for winding weft yarns varies with the different materials and in the different localities. Scales of payment are drawn up to suit the material, quality and fineness of yarn.

Linen yarns are reckoned on the basis of pence per 100 hanks according to scale.

Woollen and Worsted yarn scales of payment vary as follows :—(a) at pence per doz. hanks ; (b) at pence per lb. ; and (c) a definite number of lbs. per shilling according to sort.

Cotton yarn scales are numerous ; the chief include (a) a definite No. of lbs. per shilling ; and (b) a specified amount in pence per unit weight of 10, 50 or 60 lbs. according to quality and fineness.

Example 3.—A weft winder has a " share " of 21

spindles on each of which she can wind 60 yards per minute less 20% for *local* stoppages. (a) What quantity in bundles does she wind in one week of 48 hours and (b) what amount will she earn in wages if paid at the rate of 2/3 per 100 hanks of linen ?

(a) No of bundles per week=

Bundles per hr. × effective time in hrs.

$$= \frac{21 \times 60 \times 60}{60{,}000} \times \frac{48 \times 80}{100} = 48{\cdot}384 \text{ bundles.}$$

(b) Amount paid in wages =

Total No. of hanks wound × Rate

$$= \frac{48{\cdot}384 \times 100}{6} \times \frac{1}{100} \times \frac{27}{12} = \text{18s. 2d.}$$

Example 4.—A weft winder winds 40s grey at 1/9 ; 120s grey at 2/- and 100s bleached cotton at 2/1 per 100 hanks. Her earnings for the respective sorts are 5/6, 6/2 and 6/4. What No. of hanks does she wind per week of each sort ?

(a) No. of hanks of 40s $= \frac{100}{21} \times \frac{66}{1} = 314{\cdot}28$

(b) ,, ,, 120s $= \frac{100}{24} \times \frac{74}{1} = 308{\cdot}3$

(c) ,, ,, 100s $= \frac{100}{25} \times \frac{76}{1} = 304.$

Warping and Beaming Problems.

Warps are prepared for weaving on one of the following methods.

I. The Warping "Mill." This type and principle of machine is old and well known ; it consists of a large reel or "swift," commonly denominated the "mill," free to rotate either

in a vertical or horizontal plane—usually the former. It is made in sizes varying from 10 to 25 yards in circumference. The periphery of the swift or mill consists of wooden spokes, supported radially from the central shaft at a distance, necessary to produce the required circumference. The spokes are circumferentially 12 or 15 in. apart, the knowledge of which facilitates correct and rapid measurement of the warp length.

The warper's bobbins or spools are placed on pegs in a creel denominated the bank. The capacity of "banks" varies considerably.

Example 5.—A worsted warp is required to be made 420 yds. long and contain 4950 ends. The circumference of the warping mill is 20 yds. and there are 75 bobbins put up in the bank. Ascertain the No. of rounds which the "mill" must make to give the required length of warp also the number of "bouts" necessary to complete the total number of ends in the warp.

(a) Rounds of mill. $= \frac{\text{Length of Warp}}{\text{Circe. of mill}} = \frac{420}{20} = 21.$

(b) Bouts or single journeys $= \frac{\text{Ends in warp}}{\text{Ends in bank}} = \frac{4950}{75} = 66.$

Example 6.—It is required to make a striped warp on the "Mill" to the following pattern:—4 black, 2 twist, 4 slate, 2 twist; No. of ends exclusive of selvedges, 3840; length of warp, 210 yds. number of cuts 3. The circumference of the warping mill is 15 yds.; the distances apart of the spoke centres is

1 ft. and the bank contains 8 repeats of pattern, i.e. 96 threads. Find (a) the revolutions necessary to produce the length of warp; (b) the No. of bouts required to make up the total ends in the warp and (c) the position of the warping mill where the *first* and *second* "cuts" must be indicated.

(a) Revolutions of mill $= \frac{210}{15} = 14.$

(b) Bouts $= \frac{3840}{12 \times 8} = 40$

(c) Revs. of mill per cut $= \frac{210}{3} \times \frac{1}{15} = 4\frac{2}{3}.$

∴ Position of first cut mark = 4 rounds + 30 spokes

and ,, second ,, = 9 ,, + 15 ,,

II. Beam Warping. In Beam Warping the warp yarn is first drawn from the bobbins or spools of the warper's bank or creel and then evenly distributed over and simultaneously wound on to a flanged warp beam denominated the warper's or slasher's beam. The width of the warp yarn on this beam is slightly greater than that of the subsequent weaver's beam.

The number of warp threads put on to the beam is limited to the capacity of the banks which are constructed to hold from 500 to 1200 bobbins.

From two to eight warper's beams, constitute a "set" and their number is governed by the total number of threads required on the weaver's beam.

The full set of warper's beams is subsequently placed in a stand at the rear of the slashing machine, for cotton.

In linen manufacture, they are divided into two groups and placed one at each end of the linen dressing machine.

Example 7.—A warp is required to contain 5000 ends, the warper's bank is limited to 800. Ascertain the number of warper's beams to be made and the number of ends which each must contain.

Obviously 6 beams would be insufficient and 7 beams, inconvenient, therefore 8 beams would have to be warped as follows :—

$$\text{Ends in bank} = \frac{\text{Total ends in warp}}{\text{No. of warp beams in set}} = \frac{5000}{8} = 625.$$

Example 8.—If a beam warping machine, with 500 ends in bank can produce an effective turn off of 1800 yards per hour of 32s cotton, find (a) the total weight of yarn warped in 48 hours and (b) calculate the number of weaver's beams that could be filled, if each contained 3,000 ends of 1000 yards length—100 yds. per cut.

(a) Total weight in lbs.

$$= \frac{\text{Total length in yards}}{\text{yards per lb.}} = \frac{500 \times 1800 \times 48}{32 \times 840} = 1607\tfrac{1}{7} \text{ lbs.}$$

(b) No. of Weaver's beams=

$$\frac{\text{Total length in yards}}{\text{Total yds. of yarn on each beam}} = \frac{500 \times 1800 \times 48}{3000 \times 1000} = 14{\cdot}4$$

Example 9.—If 4 warper's beams must each contain 400 ends of 50s lea warp, laid 10500 yds., find the most suitable length of yarn which must be wound on to each warper's bobbin or spool ; also ascertain the total No. of bundles of yarn required and the

actual number of bundles on the 4 beams. Allow 100 yards per hank to cover waste in winding.

The length of linen yarn on each warper's *spool* is usually some multiple of a hank or half hank according to the counts of yarn and size of spool—the primary object is to avoid too many knots in the warping process.

The normal size of a linen warper's spool is 5×4 in. and the No. of hanks which each will approximately hold is as follows :—12s lea, 1 hank ; 18–20s, $1\frac{1}{2}$ hanks ; 25s, 2 hanks ; 35s, 3 hanks ; 50s, 4 hanks ; 60–65s, 5 hanks and so on pro rata to the counts to the nearest whole or half hank.

For a spool $5 \times 4\frac{1}{2}$, the No. of hanks would be approximately for 10s lea, 1 hank and pro rata for other counts.

Waste varies from 50 yds. to 100 yds. per hank.

(a) Then in the foregoing example, the total length of each thread in the 4 warps=

$$10500 \times 4 = 42{,}000 \text{ yards.}$$

(b) Length of each thread expressed in hanks, including waste

$$= \frac{42000 \text{ yds.}}{(3600 - 100 \text{ yds.}) \text{ yds. per hank}} = 12 \text{ hanks.}$$

In warping parlance this length is denominated a 12 " hank run " or set, for each thread in the warp.

N.B.—These hanks could be put on to 3 spools but since there are 4 warper's beams it is better to put the 12 hanks on to 4 spools.

(c) The number of warper's spools per thread or hank run

$$= \frac{12 \text{ (hanks run)}}{3 \text{ hanks (50s)}} = 4 \text{ spools.}$$

or alternatively $\frac{10500}{(3600 - 100)} = 3$ hanks per spool.

(d) Then the total No. of bundles to order

$$= \frac{\text{spools in bank} \times \text{hanks per run}}{\text{hanks per bundle.}} = \frac{400 \times 4 \times 3 \times 6}{100} = 288$$

(e) Quantity in bundles on 4 beams

$$= \frac{400 \times 4 \times 10500 \text{ yds.}}{60000 \text{ yds. per bundle}} = \text{bundles } 280$$

(f) Balance left on spools+waste in warping = 8

Example 10.—If the basis for beam warping with 500 ends in the hank is 6d. per warp of 3000 yards including creeling and if the warper's beam contains 6 warps of 32s cotton twist, what number of beams does a warper produce in one week of 48 hrs. assuming she earns 30/- per week ?

(a) The No. of warps per week $= \frac{30 \times 12\text{d. per wk.}}{6\text{d. per warp}} = 60$

(b) The No. of warper's beams per wk. $= \frac{60 \text{ wps.}}{6 \text{ wps. per beam}} = 10$

III. Sectional Warping. Warps, of various kinds of material, are frequently wound or prepared on flanged, narrow width drums, denominated " sections " or " cheeses."

The width of the drum or cheese is fixed and is usually about $4\frac{1}{2}$ ins.

The setting or closeness of the warp threads on each section coincides with that of the warp required on the weaver's beam.

The number of bobbins put up in the warper's bank must, as a natural corollary be the same as is required to be on each "cheese."

The number of cheese sections required for each warp is determined by dividing its width into that of the full width of the warp.

Example 11.—Assume a warp is required to contain 72 threads per inch and be $67\frac{1}{2}$ ins. wide on the weaver's beam. The width of the cheese sections, on which the warp is first prepared is $4\frac{1}{2}$ ins. Calculate the number of "ends" which must be put up in the bank and also the number of cheeses which must be made.

(a) No. of ends in bank = Ins. wide of cheese × Ends per in. $= 4\frac{1}{2} \times 72 = 324$.

(b) No. of cheeses reqd. $= \frac{\text{Width of warp}}{\text{Width of cheese}} = \frac{67\frac{1}{2}}{4\frac{1}{2}} = 15$.

The 15 cheeses are next placed on to a shaft in the warp beaming machine, from which they are simultaneously wound on to the weaver's beam.

If the width of the warp does not agree with a definite number of cheeses, it is usual to reduce the number of ends per cheese and correspondingly increase the width of the warp on the weaver's beam.

Example 12.—A warp is required to contain 60 ends per inch and be 62 inches wide on the weaver's beam. The width of each cheese section is $4\frac{1}{2}$ inches. Find the most convenient number of cheeses which must be made and calculate the number of ends which must be warped on to each cheese and the number of ends in the warper's bank.

(a) No. of cheeses required $= \frac{62}{1} \times \frac{2}{9} = 13\frac{2}{3}$ say 14.

(b) No of ends on each cheese and in warper's bank $= \frac{60 \times 62}{14} = 266.$

IV. Variable Sectional Warping and Beaming. The width of the section in Brown's warping and beaming machine may be varied at will. Briefly, the principle consists of a central shaft, suitably supported and free to rotate. Upon this central shaft. *thin metal disc plates* are adjusted and set screwed at lateral distances apart to suit any required width of section. The product of the widths and the number of sections gives the width of the warp yarn on the weaver's beam.

At a convenient radial distance from the central shaft a series of thin iron rods pass through perforations in the disc plates. These rods form the core on which the warp yarn is wound ; they are concentric and rotate in sympathy with the central shaft.

The yarn from the "bank" for each section is fastened to one of the concentric rods. The central shaft and rods are then rotated a pre-determined number of revolutions to produce the required length of warp.

For the next and each successive section, the warp threads from the bank are moved laterally into position directly opposite its respective division, when the operation of warping is repeated.

From the above combined sections, the warp yarn is wound directly on to the weaver's beam.

Example 13.—A worsted warp is required to be made as follows :—5360 ends ; 450 yds.; 67 inches

wide; 2/40s warp. The bank contains 500 ends. Calculate the number of sections and the width of each section, also the net weight of warp on the weaver's beam.

$$\text{No. of sections} = \frac{\text{Ends in warp}}{\text{Ends in bank}} = \frac{5360}{500} = 10 + 360 \text{ ends.}$$

$$\text{Ends per inch} = \frac{\text{Ends in width}}{\text{width}} = \frac{5360}{67} = 80$$

$$\text{Width of each section} = \frac{\text{Ends in bank}}{\text{Ends per inch}} = \frac{500}{80} = 6\tfrac{1}{4}''$$

$$\text{Width of last section} = \text{Do.} = \frac{360}{80} = 4\tfrac{1}{2}''$$

$$\text{Weight of warp} = \frac{\text{Ends in Warp} \times \text{length}}{\text{yds. per lb.}}$$

$$= \frac{5360 \times 450}{20 \times 560} = 215\tfrac{5}{14} \text{ lbs.}$$

Example 14.—A striped warp has to be made to the following pattern and particulars:—

A 2 black, 2 medium grey for 36 threads and

B 1 black, 1 light grey for 36 threads; 64 ends per in.; 63 ins. wide; length of warp 280 yards, limit of bank 500 bobbins. Calculate the number of repeats of pattern; state the number of ends to put up in the bank and show how to arrange them so as to make each side of warp alike, also the width of each and number of sections.

$$\text{No. of patterns in warp} = \frac{\text{Ends in warp}}{\text{Ends in pattern}} = \frac{64 \times 63}{72} = 56$$

To make both sides alike, begin with 2 threads for 18 threads pattern section A and finish with 2 black and 20 ends of section A.

$$\text{No. of sections} = \frac{\text{Ends in warp}}{\text{Ends in bank}} = \frac{64 \times 63}{500} = 8 + 32.$$

For convenience use 9 sections, then

$$\text{No. of ends in bank} = \frac{\text{Ends in warp}}{\text{No. of sections}} = \frac{64 \times 63}{9} = 448.$$

+2 extra ends of black for the last section.

$$\text{Width of each section} = \frac{\text{Ends in bank}}{\text{Ends per inch}} = \frac{448}{64} = 7''$$

V. Incline Plane Sectional Warping Mill.

In the " Knowles " type of warping machine, the axle of the mill is supported in a horizontal plane. The complete warp is built up in sectional widths against an *incline plane.* This inclined plane consists of wedge shaped pieces of wood, one of which is clamped to the external surface of each respective horizontal stave or spoke. Each section is usually from 5 to 6 ins. wide and contains as many threads as there are ends in the warper's bank.

The requisite number of sections is governed by the total width of warp and threads required.

Example 15.—A worsted warp is required to be made on the " Knowles' " machine and to contain 80 threads per inch ; 66 ins. wide on the beam ; 6 cuts, each 70 yds. long ; the limit of the warper's bank is 500 and the circumference of the swift is 10 yds. Ascertain (a) the number of ends which should be put up in the bank to give a complete number of sections and (b) the number of revolutions to be made by the swift for each section warped ; (c) Calculate also the weight of the warp on the beam when the yarn used is 2/36s worsted.

N.B. No. of sections for full bank $= \frac{80 \times 66}{500} = 10\frac{4}{5}$.

(1) Ends in bank $= \frac{80 \times 66}{11} = 480$

(2) Revs. of swift for each section $\frac{6 \times 70}{10} = 42$

(3) Weight of Warp $= \frac{80 \times 66 \times 6 \times 70}{18 \times 56} = 2200$ lbs.

Example 16.—Assume a warper earns 22/5 per week of 48 hrs. when paid at the rate of $4\frac{1}{2}$d. per 1000 yds. with 500 ends in the bank ; allow 16 hrs. at 5d. per hr. for re-filling the bank and 100 yds. per linen hank for waste. Ascertain (a) the total No. of yds warped ; (b) the No. of yds. of warp on each warper's beam, assuming two sets of four beams each, are required and (c) state the No. of bundles of yarn which must be ordered so as to make the above warps.

Then 16 hrs. @ 5d. = 80d. = 6/8
and 22/5 − 6/8 = 15/9 or 189d. the amount paid for actual warping.

(a) Total yards warped

$$= \frac{\text{Net amt. pd.} \times \text{basis of length}}{\text{rate of pay}} = \frac{189 \times 1000}{4\frac{1}{2}} = 42{,}000 \text{ yds.}$$

(b) Yds. per warper's beam

$$= \frac{\text{Total length}}{\text{set} \times \text{beams per set}} = \frac{42000}{2 \times 4} = 5250.$$

(c) No. of bundles of yarn to order

$$= \frac{\text{Total length} \times \text{ends in bank}}{(\text{yds. per hank} - \text{less waste}) \text{ hanks per bundle.}}$$

$$= \frac{42000 \times 500 \times 6}{(3600 - 100) \times 100} = 360$$

Example 17.—The average running of a linen warping machine is 1700 yards per hour, less 5% loss of time for starting. The banks when full carry 800 spools but vary from 350 to 750 and are double and interchangeable so that 5% covers the loss of time for starting. The number of warper's beams for each "set" is 4, 6 or 8 with an average of 5.

The dressing machines average about 220 yds per hour during the period of actual dressing, less $33\frac{1}{3}\%$ for changing beams, tieing in or crowning, getting the size and starting. Calculate from the given data, the number of dressing machines that would be kept in occupation by two warping machines.

(1) Average No. yds. warped per unit time or per hour by two warping machines, when the number of beams per set average five

$$= \frac{\text{yds. per hr.} \times \text{No. of m/cs.} \times \%}{\text{Av. beams per set}} = \frac{1700 \times 2 \times 95}{5 \times 100}$$

(2) Av. No. yds. per unit time, or per hr. for each dressing machine

$$= \text{yds. per hr.} \times \% = \frac{220 \times 66\frac{2}{3}}{100} = \frac{220 \times 2}{3}$$

$$\therefore \text{No. of dressing m/cs. reqd.} = \frac{1700 \times 2 \times 95}{5 \times 100} \times \frac{3}{220 \times 2} = 4{\cdot}4$$

EXERCISES.

General.

1. If a warp beam contains 600 ends 7200 yds long, and weighs 365 lbs, allowing 65 lbs. for the empty warp beam, find the leas per lb. linen and the hanks per lb. cotton and worsted.

Ans., 48; $17\frac{1}{7}$.; $25\frac{5}{7}$.

2. If a warp winder attends 18 drums each 9″ diameter and making 150 revolutions per minute, what length of yarn can she wind per hour if the effective surface speed of the drums is 70% ; also what number offhanks would this length represent in cotton and worsted and leas, in linen ?

Ans., 89100 yds ; 100·6 ; 150·9 ; 297.

3. If 4 warp winders as in question 2 can produce a sufficient quantity of yarn to fully employ two warpers, each making warps from a 500 end bank, find the total number of yards warped per week of 48 hrs. ; also the number of warper's beams that each warper would make, assuming each beam to contain 1250 yds. Allow 15 hrs. for refilling banks and stoppages. *Ans.*, 9·4 each.

4. A weaver's beam contains a creamed warp, the net weight of which is 90 lbs. There are 3000 ends and the length is 500 yds. The yarn lost 12½% of its grey weight in creaming, but it subsequently gained 5% in sizing or dressing. Find the counts in linen and cotton.

Ans., 51s ; 142·2.

Woollen and Worsted.

5. A spinner has in stock 1200 warping bobbins of 2/32s worsted, the average length on each bobbin being 8960 yards. How many warps, each containing 2000 ends, and 360 yards long, can be made, and what remains over ?

Ans., 14 ; 75.

6. There are in stock 13 lbs. of 20 skeins woollen. What number of ends of warp will this weight make if the warp has to be 65 yards long ? *Ans.*, 1024.

7. A worsted warp is required to be made on a 20 yds. circumference warping mill and from a bank containing 200 ends. The warp is required to be made from 2/36s worsted on to four separate balls of 1200 ends each and 350 yds. in length. Ascertain the number of revolutions of the mill and the number of bouts required to produce the correct length and number of ends respectively. State also the calculation weight of the four warps. *Ans.*, $17\frac{1}{2}$; 6 ; $166\frac{2}{3}$.

Cotton and Silk.

8. A cotton warper's beam of 5 wraps or lengths of 3500 yds. each. The number of ends on the beam is 510 of 32s twist. Calculate the net weight of yarn in lbs.

Ans., 332·03 lbs.

9. Calculate the cost of winding the following warp yarns 10 bundles of 2/24s ; 12 bundles of 32s and 15 bundles of 40s. Each bundle weighs 10 lbs. and the respective costs for winding are $4\frac{1}{2}$d., 5d. and $5\frac{1}{2}$d. per 100 hanks.

Ans., 4/6 ; 16/- ; 27/6.

10. Given 600 lbs of 3/36s cotton twist ; it is required to make four banks or warper's beams for an order containing 1680 ends for the four beams and 3600 yds. in length. Ascertain the number of ends to be put up in the warper's bank and also the length of yarn on each bobbin exclusive of waste.

Ans., 420 ; 14400.

11. If a cotton warper is paid 3/- per beam for warping 5 wraps or lengths of 1600 yds. each, assuming she earns 28/- per wk., what number of beams does she make and what would be the net weight on the beams if each contained 510 ends and the counts of the yarn was 32s twist.

Ans., $9\frac{1}{3}$ beams ; $1416\frac{2}{3}$ lbs.

12. A warper's beam contains 510 ends of 3/36s cotton and weighs 468 lbs. net. What is the total length of the warps ?

Ans., 9250 yds.

13. There are in stock 160 bobbins of 30s cotton with an average weight of 8 ounces of yarn. Allowing 5 per cent. for material left on the bobbins and for waste, what length of warp can be made with 3600 ends ?

Ans., 532.

14. Given 50 lbs. of 40s twist cotton. A warp is required to contain 2080 ends. What will be the length of the warp after allowing 5% for waste in working up.

Ans., $767\frac{4}{13}$.

Linen, Hemp and Jute.

15. Assume the capacity of the creel or "bank" for a 10 yards warping mill is 100 and that a warp is required to be made with 1680 ends and 450 yards long. Find (1) the most suitable number of bobbins to put in the warper's creel, *i.e.* the highest number divisible into 1680 which the creel will hold; (2) the number of revolutions of the mill to produce the required length of warp; (3) the number of single journeys or "bouts" necessary to produce the requisite number of threads.

Ans., 84 bobbins; 45 rev.; 20.

16. If a set of 4 warping beams each contain 464 ends, 10600 yds. long; what quantity in bundles, of linen yarn would be required and about how many yards should be wound on to each cheese or bobbin of 45s lea?

Ans., 327·89 bundles; 3 hanks per bobbin.

Note.—The manufacturer would order about 334 bundles thus allowing about $2\frac{1}{2}\%$ for waste.

17. If the total weight of each beam in the previous question is 420 lbs. and the weight of each empty warp beam is 60 lbs., what is the lea of the yarn? Also if 10% size is added what would be the weight of each cut, laid 100 yds. on the weaver's beam?

Ans., 45·54; 15.

18. If a winder with 20 ends makes 18/- per week at 1/- per 100 hanks of linen, how many winders would be required to keep three warpers going who make 22/6 per week. being paid 9d. per 1000 yds. of a 350 end bank allowing 100 yards per hank for waste?

Ans., 5.

19. What time will be required to fill a warper's spool which holds 4 hanks of linen yarn, if the rate of winding is 150 yds. per minute and the effective running is 70%?

Ans., 134·5 min.

20. If 400 5/4 plain looms turn off 500 webs per week and require an average of $5\frac{1}{5}$ bundles of warp yarn for each web

and also if each warp winder attending 18 drums can wind an average of 80 bundles per week, ascertain the total number of winding drums required and the average number of drums required per loom.

Ans., 585 ; 1·46.

21. If 4 warp winders earn, per week, an average of 17/3, 17/7½, 18/- and 18/4½ for winding respectively 10s to 60s lea at 15¾d., 60s to 70s lea at 17¼d., 75s to 100s lea at 18d. and 110s to 130s grey at 20¼d. per 100 hank. Calculate the number of bundles of yarn that must be wound of each sort to balance the above amounts ; also state the average number of bundles wound per winder per week.

Ans., 78·857 ; 73·565 ; 72 ; 65·4 ; 72·45.

22. A weft winder is paid 1/7, 1/8, 1/9, 1/10 and 1/11 per 100 hanks each of five different sorts of flax lea Nos. Find (a) the number of bundles of each sort which must be wound to earn 18/- per week and (b) the average number of bundles wound per week per winder for all the sorts.

Ans., (a) 68·21, 64·8, 61·72, 58·9, 56·4 ; (b) 62.

CHAPTER IX.

"Set Systems" or Various Systems of Counting Reeds and Healds.

The proximity of the warp threads to each other in the process of weaving, and subsequently in the woven structure, is represented by the relative number of mails in the healds, or splits in the reed distributed over some fixed unit of space, including the number of warp threads which are passed through each split in the reed.

This fineness, or distance apart of the warp threads, is technically termed the "SET."

The number of threads, mails, or splits and unit of measurement, which may indicate the Set is optional, and this fact accounts for the introduction of so many different methods of counting reeds and healds.

Obviously, the simplest basis which is conceivable for a "Set System" that ought to be generally adopted, is to indicate the Set by the number of threads per inch, at least in all countries where the British measurements are used, and for the Continent the number of threads per centimetre appears the most feasible. But individual enterprise and locality of industry have long since established their respective systems, so that to-day there is a considerable number in use. It is, consequently, advisable for those interested in the manufacture of woven structures to

acquaint themselves with the principles which underlie the system in use in their own locality, and also a few of those most generally adopted. For this reason, a few typical examples of Set Systems have been collected and herein described and tabulated for use and convenient future reference.

At this juncture, it should be pointed out that the technical terms frequently employed in connection with Sets of reeds and healds, such as Beer, Portie, Porty, Porter, and Groups of Splits, are all arbitrary in name and value, each of which is made to represent a group of warp threads, which, being spread over any fixed number of inches, is made to represent the Set.

The Bradford System of designating *Sets* is based upon the "BEER" of 40 ends each, in a standard width of 36 inches, or of 20 splits, with 2 threads in each split in the standard width of 36 inches. An explanation of this system in detail will form the key to understanding the several systems herein enumerated.

The arbitrary term "Beer" represents the *unit* number of threads grouped together. The standard width of 36 inches represents the *unit measurement* across the width of the reed. Consequently, if 40 threads be distributed over a distance of 36 inches, the Set Bradford would be 1s; if 80 threads, then 2s Set; and 120 threads, then 3s Set Bradford.

Example 1.—If in a reed of 30 inches width there are 3000 threads, the Set would then

$$= \frac{3000 \times 36}{30} = 3600 \text{ ends in 36 inches,}$$

and $\frac{3600}{40} = 90$ Beers of 40 ends each in 36 inches,

$\therefore$ 90s Set Bradford.

Example 2.—A cloth is woven in 72s Set Bradford. To how many ends per inch is this equivalent ?

Since each Set is equivalent to 1 Beer, then 72s Set = 72 Beers, and each Beer contains 40 threads when the standard width is 36 inches.

$\therefore$ The number of threads per inch $= \frac{72 \times 40}{36} = 80$.

A very important point should here be emphasised with respect to reeds or sleys, *e.g.*, a 50, 54, 60 or 80 sley Bradford Set would indicate that these reeds would respectively contain $50 \times 20 = 1000$; $54 \times 20 = 1080$; $60 \times 20 = 1200$; $80 \times 20 = 1600$ splits in a standard width of 36 inches. Hence, these reeds when sleyed 2 threads through each split would produce a fabric in the above Sets respectively. But very frequently any of these reeds may be woven with 3, 4, or more threads through each split, and then the Set is greater in the ratio as 3 is to 2 ; 4 is to 2, etc., and similarly with other systems, thus *e.g.*, a 50/3 sley, *i.e.*, 3 in a dent or split, instead of 2, would equal

$$\frac{50 \times 3}{2} = 75\text{s Set Bradford}$$

or 60/4 sley Bradford $= \frac{60 \times 4}{2} = 120\text{s Set Bradford}$.

The *Leeds System* is based upon the number of Porties of 38 ends each, in 9 inches, so that 1s Set or Portie Leeds contains 38 threads distributed over a unit distance of 9 inches, and 10s Portie Set would

represent 380 threads distributed over the 9 inches, or an average of $\frac{380}{9} = 42\frac{2}{9}$ threads per inch over any width of cloth in the reed.

The *Huddersfield present System*, which is the most rational, is based upon the number of dents or splits per inch in the reed multiplied by the number of threads passed through each split; then, 15s reed 4s implies that the cloth is woven in a reed which has 15 splits per inch, and that 4 threads are passed through each split, which is consequently equal to 60 ends per inch.

The *U.S.A. System* is also based upon this method.

In the *Dewsbury System*, the Beer has a value of 38 ends, and the standard width is 90 inches; the system is therefore based upon the number of Beers of 38 ends each, in 90 inches, or 19 splits 2 ends in a split in 90 inches.

THE PRINCIPAL TOWNS IN LANCASHIRE.

The *Bolton System* is based upon the Beer of 40 ends each, in a unit distance of $24\frac{1}{4}$ inches, or 20 splits 2 ends in a split in the standard width of $24\frac{1}{4}$ inches.

In *Manchester*, the method adopted is based upon the number of splits of 2 threads each in 36 inches, thus:

$$900 \text{ Manchester} = \frac{900 \times 2}{36} = 50 \text{ threads per inch.}$$

At *Stockport*, the system is based upon the number of splits (2 ends to a split) in a distance of 2 inches, which is equivalent to the number of threads per inch, *e.g.*, 60s Stockport equals 60 ends per inch or 60 splits in 2 inches, 2 ends in a split.

The Scotch Systems.

The *Glasgow Cotton System* is based upon the number of splits, 2 ends in a split, in 37 inches ; thus a cloth woven 60 threads per inch is equal to

$\frac{60 \times 37}{2} = 1110$ Set Glasgow, usually written, thus 11^{10}

The *Scotch Tweed* is based upon the number of Porters of 40 ends each in 37 inches, or of 20 splits each, 2 ends in a split in the unit distance of 37 inches.

Linen, *Belfast and North of Ireland.*

The " Scale " or System most generally adopted is based upon the number of dents or splits, 2 ends in a split, in a standard width of 40 inches, *e.g.*, 8°° ; 10°° ; 12°° and 13°° indicate that in a reed width of 40 inches there are 800, 1000, 1200, and 1300 splits respectively. Usually these would be sleyed 2 ends through each split, but for the finer sorts there may be 3, 4 or more threads through each dent in which case the set would increase *pro rata.*

Example.—A fabric is woven in 10°° reed 3 threads in a split, find the usual set.

$$\frac{1000 \times 3}{2} = 15^{\circ\circ} \text{ set.}$$

Note.—36, 37 (Glasgow), 38, and 41 inch scales are also used, but the 40 inch basis may be said to be virtually the *linen* scale, because of its most general adoption.

Damasks, Linen.—There are several systems in use. (1) The old method of counting the number of Beers of 40 ends each in the full width of the warp ; (2) the number of Beers of 40 ends each in a standard width of 30 inches ; (3) in some few cases the Scotch system

of reckoning the number of Porters of 40 ends each in the Scotch ell of 37 inches; (4) The more rational system of ends per inch multiplied by the reed width is being gradually adopted.

The *Silk System* of representing the Set is based upon the number of splits in the full width of the warp, and the Set multiplied by the number of threads through each split indicates the total number of ends in the whole warp, thus, warp 21 inches wide, 5 threads in each dent, 2100 Set = 2100 × 5 = 10,500 ends.

Since in every system it is frequently necessary to obtain the Set after having first decided upon the threads per inch which the cloth must contain, or to reduce any given Set to threads per inch, a few examples are here worked out and reduced to simple formulæ for use in practice.

Example 1.—If a cloth must contain 80 threads per inch, what Set is equivalent to this in Bradford, Leeds, Dewsbury, Manchester, Scotch Tweed, and in Linen 40 in. scale and Damask No. of Beers on 30 in. scale?

(a) Bradford, 40 threads = 1 Beer,

and $\frac{80}{40}$ = 2 Beers in 1 inch.

Since the standard number of Beers = 36.

Then 2 × 36 = 72 Beers in 36 inches = 72s Set.

(b) Leeds, 38 threads = 1 Portie,

and $\frac{80}{38} = 2\frac{2}{19}$ Porties in 1 inch.

Since the standard width = 9 inches.

Then $2\frac{2}{19} \times 9 = 18\frac{18}{19}$ Porties in 9 inches $= 18\frac{18}{19}$s Set.

(c) Dewsbury, 38 threads = 1 Beer.
Standard width = 90 inches.

$$\therefore \frac{80}{38} \times \frac{90}{1} = 190\text{s Set (nearly).}$$

(d) Manchester,

$$\frac{80 \times 36}{2} = 1440 \text{ Splits in 36 inches} = 1440\text{s Set.}$$

(e) Scotch Tweed,

$$\frac{80 \times 37}{40} = 74 \text{ Porters in 37 inches} = 74\text{s Set.}$$

(f) Linen 40 in. Scale,

$$\frac{80 \times 40}{2} = 16^{00} \text{ Set.}$$

(g) Damask—30 in. Scale,

$$\frac{80 \times 30}{40} = 60 \text{ Beers.}$$

The foregoing is best expressed in the following formulæ, which will be found of general application.

Formula XVII. applies to the method of finding the Set in any required denomination when ends per inch are known, and is as follows :—

$$\frac{\text{Ends per inch} \times \text{standard width in inches}}{\text{Number of threads in Beer, Portie or Split}} = \text{Set.}$$

If it is required to find the ends per inch, when the Set is given, then the above formula simply requires to be modified as follows :—

FORMULA XVIII.

$$\frac{\text{Set} \times \text{No. of threads in Beer, Portie or Split}}{\text{Standard number of inches.}} = \text{Ends per inch}$$

Example 2.—Given

18^{50} Set Glasgow and Linen 40 inch Scale.

12s reed 4s Huddersfield.

Find ends per inch.

(a) Glasgow, $\frac{1850 \times 2}{37} = 100$ ends per inch.

(b) Linen, $\frac{1850 \times 2}{40} = 92\frac{1}{2}$ ends.

(c) Huddersfield, $\frac{12 \times 4}{1} = 48$ ends per inch.

If it is required to change from any given system to another for any purpose whatever, it is only necessary to refer to formula XVII. and XVIII., and apply these to the solving of such problems as above. Since formula XVIII. gives the ends per inch for any given Set, and formula XVII. supplies the Set for any known ends per inch, it is only required to multiply formula XVIII. by formula XVII., omitting the ends per inch in formula XVII., thus :—

FORMULA XIX.

applies to the method of changing from any given Set in any given system to an equivalent Set in any other system.

$$\frac{\text{Given Set} \times \text{No. of threads in Beer}}{\text{Standard width in inches}} \times \frac{\text{Standard width in inches}}{\text{Threads in Beer of Set}} = \text{Required Set.}$$

Example 3.—Given 1260 Set Manchester, find its equivalent Set in Bradford and Belfast.

Then by formula XIX.,

(a) $\frac{1260 \times 2}{36} \times \frac{36}{40} = 63$ Set Bradford.

PROOF.—1260 splits, 2 in a split = 2520 threads in 36 inches. $2520 \div 36 = 70$ threads per inch.

And, $70 \div 40 = 1\frac{3}{4}$ Beers per inch.

$\therefore\ 1\frac{3}{4} \times 36 = 63$ Beers of 40 ends each in 36 ins.

(b) $\dfrac{1260 \times 40}{36} = 1400$ Belfast.

For future and easy reference, all the foregoing details are tabulated and concisely arranged in Table III.

Various other Examples.

Example 4.—If a warp containing 2000 ends has to be sleyed 2 ends in a split over a width of 36 inches, what would be the Set in Scotch Tweed and Huddersfield ?

By formula XVII.,

Scotch Tweed $= \dfrac{2000}{36} \times \dfrac{37}{40} = 51\frac{7}{18}$s Set.

Huddersfield $= \dfrac{2000}{36} \times \dfrac{1}{2} = 27\frac{7}{9}$s reed 2s Set.

Example 5.—If a warp contains 100 Beers in a width of 60 inches ; what is the Set Bradford ?

By formula XVII.,

$$\left(\frac{100 \times 40}{60}\right) \times \frac{36}{40} = 60\text{s Set Bradford.}$$

Example 6.—Given a warp 72 Beers to be woven 54/3 Bradford, what is the reed width ?

Then $54/3 = \dfrac{54 \times 3}{2} = 81$s Set Bradford.

and $72 \times 40 =$ total number of threads in warp.

Also $\dfrac{81 \times 40}{36} =$ ends per inch of warp.

$$\therefore\ \frac{72 \times 40}{1} \times \frac{36}{81 \times 40} = 32 \text{ inches in width.}$$

TABLE III.

Various Systems of Counting Reeds and Healds.

		Locality and System.	Standard width in Inches.	No. of threads in 1 Beer, Portie, Porter, etc.	No. of splits in 1 Beer, etc., reckoning 2 ends in each split.	Given ends per inch to find set, multiply by — Ordinary	Given set to find ends per inch multiply by — method.	Given ends per inch to find set. — Short	Given set to find ends per inch. — method.
								deduct	add
YORKSHIRE.	1	Bradford ...	36″	40	20	$\frac{36}{40}$	$\frac{40}{36}$	$\frac{1}{10}$	$\frac{1}{9}$
	2	Leeds ...	9″	38	19	$\frac{9}{38}$	$\frac{38}{9}$		
	3	Hudd'fd. & U.S.A.	1″	Splits	per inch	× ends	in split		
	4	Dewsbury ...	90″	38	19	$\frac{90}{38}$	$\frac{38}{90}$		

5	Bolton ...	$24\frac{1}{4}$"	40	20	$\frac{24\frac{1}{4}}{40}$	$\frac{40}{24\frac{1}{4}}$	Formula		
6	Manchester ...	36"	2	No. of splits in unit width.	$\frac{36}{2}$	$\frac{2}{36}$	× by 18	÷ by 18	
7	Stockport ...	2"	2	1 =	Threads	per	inch.		
8	Glasgow ...	37"	2	No. of splits in unit width.	$\frac{37}{2}$	$\frac{2}{37}$			
9	Tweed ...	37"	40	20	$\frac{37}{40}$	$\frac{40}{37}$			
10	Linen, Plain, etc...	40"	2	No. of splits in unit width.	$\frac{40}{2}$	$\frac{2}{40}$	× by 20	÷ by 20	
11	,, Damask ...	30"	40	20	$\frac{30}{40}$	$\frac{40}{30}$	$\frac{1}{4}$	$\frac{1}{3}$	
12	,, ,, ...	37"	2	20	$\frac{37}{40}$	$\frac{40}{37}$			
13	,, ,, ...	Ends	per inch	× reed	width.				
14	Silk	Width of Fabric.	No. of Ends through each split.	No. of splits in total width of piece.					

Ends per in. x width in inches. / No. of ends in each split.

Set x ends in each split. / Width in inches.

LANCASHIRE | SCOTCH | IRELAND AND NORTH OF IRELAND.

Varieties in Fineness or Crammed Stripes.

Example 7.—It is required to make a crammed stripe in a 66 sley Bradford woven,—

60 ends of 2/80s cotton, 2 in a split, plain weave.

60 ends of 40/2 spun silk, 5 in a split, sateen weave.

Reed width 29 inches.

Find the number of threads of each sort, the total number of ends in the whole warp, and also the average Set Bradford.

Then, $\frac{60}{2}$ = 30 splits of 2/80s cotton.

and $\frac{60}{5}$ = 12 splits of 40/2s spun silk.

Therefore 30 + 12 = 42 splits in 1 repeat of pattern.

Also, 66 Bradford = $\frac{66}{2} \times \frac{40}{36} = \frac{110}{3}$ splits per inch.

Further, $\frac{110}{3} \times 29$ inches = $\frac{3190}{3}$ splits in total width of reed.

Then (1), $\frac{3190}{3} \times \frac{30}{42} \times \frac{2}{1}$ = 1520 ends of cotton.

Also (2), $\frac{3190}{3} \times \frac{12}{42} \times \frac{5}{1}$ = 1520 ends of silk.

$\therefore$ (3), 1520 + 1520 = 3040, total threads in warp.

(4), Then by formula XVII., *page* 159

$\frac{3040}{29} \times \frac{36}{40}$ = 94 average Set Bradford.

Note.—In order to save expense it would be advisable to commence and finish with 60 ends of cotton. This would save one pattern of silk without increasing the total number of ends and would not in any way alter the effect of the cloth.

Calculation of the Mails on each Shaft and Per Inch for Straight and Specially Drafted Patterns.

When the warp threads are drawn through the healds in arithmetical order and similarly repeated, then the calculation is simple, thus—

Example 1.—A 4-end twill pattern has to be woven with 60 threads per inch, what number of mails per inch upon each heald shaft is required? Then, since 4 heald shafts are necessary to weave the 4 shaft twill design, the number of mails per inch upon each heald shaft would necessarily be

$$\frac{60 \text{ (ends per inch)}}{4 \text{ (heald shafts)}} = 15 \text{ mails per inch per shaft.}$$

The total number of mails on each heddle would therefore be the product of the mails per inch and the width of the warp required to be woven.

Example 2.—If for the same Set a six shaft design was required to be produced, then 6 healds would be necessary, and consequently

$$\frac{60}{6} = 10 \text{ mails per inch per shaft.}$$

Supposing the warp threads have to be drawn through the mails of the healds in any special order for any purpose whatever, then if the number of warp threads drawn through the mails of each heald shaft are not exactly the same in each repeat of the draft, the number of mails per inch upon each heald shaft in the aggregate will bear the same relation to the number of warp threads upon each respective shaft,

as is shown in the heald drafting plan, Fig. 1, where the horizontal lines represent the heald shafts; the vertical lines, the warp threads, and the crosses (×) show the order in which they are drawn through the mails of the healds. The total number of threads in each repeat of the draft plan is 18, and the number of mails upon each shaft in one repeat of the draft is respectively 3, 7, 6, and 2, as shown by the figures at the right hand side of the draft.

If it now be assumed that the cloth with which this draft is employed has to contain 90 threads per inch, what number of mails per inch must each shaft contain to suit the above draft.

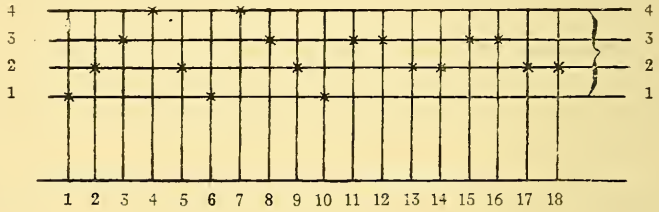

Fig. 1.

Then, since there are 90 threads per inch, and one repeat of the draft contains 18 threads.

$$\therefore \frac{90 \text{ threads}}{18 \text{ threads}} = 5 \text{ repeats of the drafts in 1 inch.}$$

Then the number of repeats of the draft, multiplied by the number of threads upon each shaft in one repeat of the draft, represents respectively the number of mails per inch required upon each shaft, thus :—

1st shaft	...	$5 \times 3 = 15$
2nd shaft	...	$5 \times 7 = 35$

3rd shaft ... $5 \times 6 = 30$
4th shaft ... $5 \times 2 = 10$
Total mails per inch = 90

The foregoing reduced to its simplest form reads thus :—

FORMULA XX.

$$\frac{\text{Ends per inch of cloth} \times \text{ends on each shaft in 1 repeat of draft}}{\text{Number of ends in one repeat of the draft}} = \text{mails per inch on shaft.}$$

Example 3.—If the draft given at Fig. 1 were employed in a 66 Set Bradford, what number of mails per inch should each shaft then contain ?

Ends per inch by formula XVII. $= \frac{66 \times 40}{36} = \frac{220}{3}$

By formula XX.,

1st shaft $\frac{220}{3} \times \frac{3}{18} = 12\frac{2}{9}$
2nd shaft $\frac{220}{3} \times \frac{7}{18} = 28\frac{1}{2}\frac{4}{7}$
3rd shaft $\frac{220}{3} \times \frac{6}{18} = 24\frac{4}{9}$
4th shaft $\frac{220}{3} \times \frac{2}{18} = 8\frac{4}{2}\frac{4}{7}$
Total mails per inch $= 73\frac{1}{3}$

SPECIALLY KNITTED (SPACED) HEDDLES.

For striped and drafted patterns including crammed stripes where the pattern is set finer in some parts than in others it is better to knit the healds to suit the design. The advantage of this is to reduce any friction upon the warp caused by the mail cords being drawn more to one side than the other.

When this plan is adopted the finest set on one or more heddles of the same fineness is taken as the pitch at which the knitting machine is made to knit the healds. All the remaining heddles are then knitted to this same scale according to their relative fineness and spaced as indicated by the requisite drafted pattern. Without entering into the details of the construction of the heald knitting machine, suffice it to say that it is usually constructed to automatically knit or miss, at will, any cord or number of cords in succession on each shaft. It is usual to base the *rate* of knitting on 4 shafts for the finest count of heald in the set.

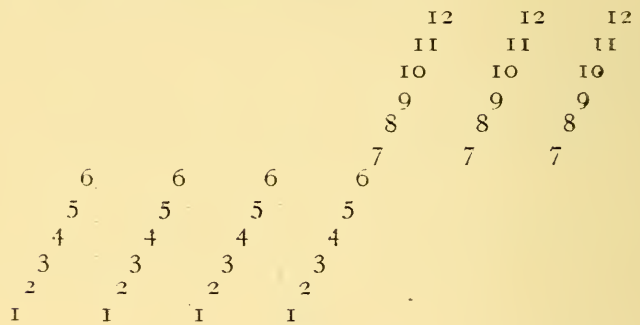

Fig. 2.

Example 1.—Given the spaced draft at Fig. 2, find the rate and order of knitting for 72 ends per inch. Then the fineness of the set in each successive group of threads on the front six and back six heddles must be equal to 72 threads per inch to coincide with the reed and fineness of fabric required.

The rate of knitting on 4 heddles will therefore be in direct ratio of 6 to 4, thus :—

As 6 heddles : 4 heddles : : 72 set : 48 set or knitting rate on 4 shafts.

The healds would then require to be knitted as follows :—

Heddles 1 to 6 knit 4 and miss 3.

,, 7 to 12 ,, 3 ,, 4.

Example 5.—Given draft as at Fig. 3 for a cloth containing 48 threads per inch. Find the knitting rate and the order of knitting so as to properly space the mails on each shaft.

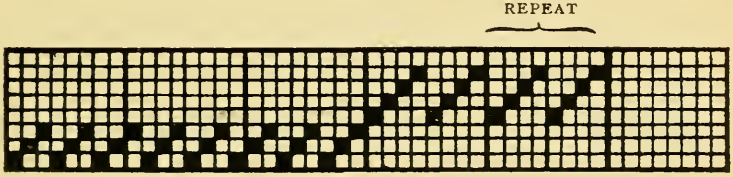

Fig. 3.

Then since the heddles must contain 48 mails per inch *pro rata* for the first 3 and the back 4 heddles :—

$$\text{Rate for heddles 1, 2 and 3} = \frac{48 \times 4}{3} = 64,$$

$$\text{and ,, ,, 4, 5, 6 and 7} = \frac{48 \times 4}{4} = 48.$$

Also for heddles 1, 2 and 3, knit 8 miss 6—Rate 64, and ,, ,, 4, 5, 6 and 7, ,, 6 ,, 8— ,, 48.

Without multiplying examples, the principle is the same for all spaced and drafted patterns required to be knitted to pattern.

EXERCISES.

General.

1. A reed contains 1320 splits in 33 inches. (a) Find the Set Bradford, 2 in a split ; (b) linen system 40″ scale.

Ans., 72 ; 16°°.

2. Reduce 80 Set Bradford to Scotch tweed, Stockport and plain linen 40″ scale systems.

Ans., $82\frac{2}{9}$; $88\frac{8}{9}$; 17^{80}.

3. Reduce 20^{50} Glasgow to Manchester, Bolton, Stockport and Belfast 40″ scale.

Ans., 1994 ; 67 ; 111 ; 2216.

4. A pattern of cloth is made with the drafting given below, using 70 threads per inch. What are the counts of the healds on each shaft respectively ?

Draft =

			6			
		5	5		5	
	4		4	4		4
3			3			3
2						2
1						

Ans., 5 ; 10 ; 15 ; 20 ; 15 ; 5.

5. A warp containing 2800 ends is to be distributed over 40 inches reed space and sleyed 3 in split. Give suitable reed—Stockport, Bradford & Belfast.

Ans., 46·6 ; 42 ; 933·3.

6. Find the average number of mails per inch for draft supplied at Figs. 2 and 3, with 72 and 48 ends per inch respectively.

Ans., $6\frac{6}{7}$ and $5\frac{1}{7}$; 8 and 6

Woollen and Worsted.

7. A cloth has to be woven in 90s Set Bradford 4 threads through each split ; how many splits per inch must the reed contain ?

Ans., 25.

8. A worsted warp which contains 2346 ends has to be woven in 64 Set Bradford 2 threads in a split ; What width should the warp occupy in the reed ?

Ans., 33 ins.

9. A woollen warp of 1520 ends has to be woven 72 inches wide in the reed. What is the Set Leeds ?

Ans., 5.

10 Find the Set of 24/3 Scotch tweed in Dewsbury, Leeds and Huddersfield 2 in a split.

Ans., 92 ; 9·2 ; $19\frac{1}{2}$.

11. A woollen warp contains 76 Porties Dewsbury ; it has to be sleyed in a 95 Set Dewsbury. What is the reed width ?

Ans., 72 ins.

12. Given 120 threads per inch, ascertain the set Bradford, Huddersfield (4 in a dent), Dewsbury and Scotch tweed.

Ans., 108 ; 30/4 ; 284 ; 111.

13. If a 40 Porter Set Scotch tweed, 37″ Scale, contains 1644 threads, what is the width in the reed ?

Ans., 38 ins.

14. A woollen warp contains 5760 threads. It is required to be set 72 inches wide in the reed. What is the Set Leeds, Bradford and Huddersfield, 4 in a split ?

Ans., $18\frac{18}{19}$, 72, 20/4.

15. A warp contains 2275 threads and is required to be woven in 64 Set Bradford, what is the width in the reed ?

Ans, 32 ins.

16. If a warp is set 66 inches in the reed and woven 88 Set Bradford, what is the total number of ends in the warp ?

Ans., 6453.

17. A pattern has to be drafted on to five heald shafts. The number of ends upon each shaft in one repeat of the draft is respectively 6, 7, 8, 9, 5. What number of mails per inch are required, if the pattern has to be 90s Set Bradford ?

Ans., $17\frac{1}{7}$, 20, $22\frac{6}{7}$, $25\frac{5}{7}$, $14\frac{2}{7}$.

18. If the draft specified in question 17 had to be woven in 80 Set Bradford, how many mails per inch would each shaft require ?

Ans., $15\frac{15}{63}$; $17\frac{49}{63}$; $20\frac{20}{63}$; $22\frac{54}{63}$; $12\frac{11}{63}$.

19. If a striped cloth is made in a 60/2 sley Bradford, having 40 ends, 2 in a dent (plain weave), 80 ends 4 in a dent (broken sateen), reed width $28\frac{1}{2}$ inches, state what number of ends would be required, and what would be the Set of the healds.

Ans., 2850 ; 90.

20 A figured pattern, of which one repeat occupies 5 inches, is made as follows :—The first inch contains 5 ends in each dent, the remaining 4 inches have only 2 threads

through each dent, the width of the fabric in the reed is 30 inches, and the total number of ends is 2400. Find (1) the average Set of the healds, (2) the sley, (3) the Set of the finer portion of the stripe, and (4) the coarser portion, all in the Bradford system.

Ans., 72 ; $55\frac{5}{13}$; $138\frac{6}{13}$; $55\frac{5}{13}$ respectively.

Cotton and Silk.

21. A cotton fabric is woven 3 threads in a dent, 42 inches wide, and contains 2520 ends. What is the Set Bolton, and how many dents per inch does the reed contain ?

Ans., 20 ; 36·2.

22. A warp contains 2102 ends which must be woven in 30 Set Bolton, 2 in a split ; What is the width in the reed and the dents per inch.

Ans., $42\frac{1}{2}$; 25 approx.

23. A cotton huchaback is sleyed alternately 3 and 2 ends per dent ; if the warp averages 70 threads per inch, what is the actual set of the reed, Stockport ?

Ans., 56.

24. A cotton cloth is made in which the warp contains 3328 ends, it is set 40 inches wide in the reed, and dented as given below. Find the average number of splits per inch of the reed.

30 ends, 2 in a split
20 ends, 1 in a split
{ 12 ends, 2 in a split
Miss one split.
12 ends, 2 in a split
Miss one split. } Repeat 58 times.
12 ends, 2 in a split
20 ends, 1 in a split
30 ends, 2 in a split

Ans., $59\frac{1}{4}$.

25. The following silk warps are woven 1800 ends 2 in a dent and 2000 ends 4 in a dent. Ascertain the ends per inch of each if woven in a reed 24 inches wide.

Ans., 150 ; 333·3.

Linen, Jute, etc.

26. A linen warp containing 3300 ends is required to be woven in 20°°, 40 inch scale, find the reed width ; also find the number of splits in 37″ scale if a warp with 2660 ends is woven 41 inches in the reed.

Ans., 33″ ; 12°°.

27. Assume a 3 end drill is woven 3 in a dent, in a 12°° reed, 40 inch scale, find (a) the ends per inch ; (b) the total number of ends and (c) the set for the usual scale.

Ans., 90 ; 3600 ; 18°°.

28. Given 60 beer damask on 30 inches find its equivalent in the plain linen scale on 40 inches and the No. of Porters, Scotch, on 37″ scale.

Ans., 16°° ; 74.

29. Given 15°° set of 40″ and 37″ scales respectively allow 5% for shrinkage in each case and find the ends per inch in cloth.

Ans., 78·9 ; 85·3.

30. (a) What plain reed would be used with three ends per split, to weave a 90 beer drill ?

(b) What would a 16°° drill be termed in beers ?

(c) A reed counts 75 splits on 4 inches, find the set on the 40 inches scale.

Ans., (a) 16°° reed 3 in a split ; (b) 60 beer ; (c) 750.

31. A linen huckaback is 24½ ins. wide in the reed and sleyed in 686 splits. What is the set of same on 40″ scale ? What heddles and draft would be used for same ? Also supply the mails per inch on each shaft.

Ans., 1400 ; 2 shafts 14 and 2 shafts 21 each.

CHAPTER X.

Quantities and Weight of Warp and Weft in Plain and Fancy Fabrics.

To the spinner and manufacturer, calculations under this heading are among the most useful and necessary. The method of solution will be best demonstrated by a consideration of the following examples :—

Example 1.—Find the weight of a warp 75 yards long, made from 2/36s Botany and woven 18s reed 4s in a 66 inch reed.

Then, the total length in yards divided by the number of yards per lb. represents the total weight in lbs., which is simply a modification of formula I., thus :—

FORMULA XXI.—Weight of Warp.

$$\frac{\text{The No. of threads per inch} \times \text{inches wide} \times \text{length of warp}}{\text{Yards per lb.}} = \text{weight in lbs.}$$

$$= \frac{72 \times 66 \times 75}{(18 \times 560) \text{ yds. per lb.}} = 35\tfrac{5}{14} \text{ lbs.}$$

Example 2.—Find the weight of weft required to weave a piece 63 yards long, 64 inches wide in the reed, made from 70 yards of warp and containing 84 picks per inch of 1/16s worsted ; add 5% to the actual weight of weft put into the cloth to cover the waste in weaving.

Then, the number of picks per inch × number of inches wide equals the number of yards of weft in 1

yard of cloth. And this number of yards × the length of cloth in yards equals the total number of yards actually put into the cloth. Thus,

$$\frac{\text{Picks per inch} \times \text{width in reed} \times \text{length of piece out of loom}}{\text{Yards per lb. of weft}} = \text{actual weight of weft in cloth.}$$

To the above must be added the allowance made for waste in weaving, but a better method is to treat the waste as part of the original problem, and state it thus :—

FORMULA XXII.

$$\frac{\text{Pks. per inch} \times \text{reed width} \times \text{piece length grey} \times (100 + \% \text{ for waste})}{\text{Yards per lb. of weft} \times 100} = \text{weight of weft to be purchased.}$$

Then by Formula XXII.,

$$\frac{84 \times 64 \times 63 \times 105}{16 \times 560 \times 100} = 39{\cdot}7 \text{ lbs.}$$

Very frequently the length of the warp is taken instead of the piece length, the difference in length being considered sufficient to cover the extra cost for waste of weft during weaving, and preferable to adding a certain percentage to the actual weight of the weft put into the piece.

Example 3.—A piece is woven from 65 yards of warp, 2/48s Botany, 54 Set Bradford, 64 inch reed, 56 picks per inch, 1/24s Botany. Find the weight of warp and weft required. The length of the warp to be taken to cover the waste of weft in weaving.

The weight of warp equals, by formula XXI.,

$$\frac{54}{36} \times \frac{40}{24} \times \frac{64 \times 65}{560} = 18\tfrac{4}{7} \text{ lbs.}$$

And the weight of weft, substituting picks for ends per inch of the same formula, equals

$$\frac{56 \times 64 \times 65}{24 \times 560} = 17\tfrac{1}{3} \text{ lbs.}$$

Quantitative Calculations for Linen Warp and Weft.

Example 4.—Given a 40's lea warp and weft woven in 12°° reed, 40 inch scale, 40 inch reed width, laid 85 yards with 12 shots of weft to 37 inch glass, producing 75 yards of cloth. Find the quantities in bundles and weight of warp and weft. Add 5% for loss of weight in warp and weft.

Warp.—(1) The number of bundles

$$= \frac{\text{Total ends in warp} \times \text{length in yds.}}{\text{Yards per bundle}} + \% \text{ for waste, etc.}$$

$$= \frac{1200 \times 2 \times 85}{60{,}000} \times \frac{105}{100} = 3{\cdot}57 \text{ bundles or 3 bdles, 9 hanks, 6 cuts.}$$

(2) The weight of warp

$$= \frac{\text{Set} \times \text{reed width}}{\text{Scale of reed}} \times \frac{\text{Length of warp in yds.}}{\text{Yds. per lb. of yarn}} + \% \text{ of waste, etc.}$$

$$= \frac{2 \times 1200 \times 40}{40} \times \frac{85}{300 \times 40} \times \frac{105}{100} = 17 \text{ lbs. } 13\tfrac{3}{5} \text{ ozs.}$$

$$\text{or } \frac{3{\cdot}57 \text{ bundles} \times 200}{40} = 17{\cdot}85 \text{ lbs.}$$

Before attempting to determine the quantity or weight of weft required for any given web, it is first necessary to understand the method of counting the shots or picks of weft put into the fabric. In the linen trade the mode of reckoning is frequently based upon the number of shots under a 37″ glass. The unit distance covered by this measure or glass is $\frac{37}{200}$ part of one inch=0·185″. The French glass for counting

linens=5 mm.=0·197″, and the Spanish glass= 6 mm.=0·236″. From the foregoing data it follows that the number of shots of weft counted under a 37″ glass multiplied by 200 gives the number of shots in 37″ of linen fabric. And since 37 inches are frequently measured to each yard of cloth it therefore represents the number of picks per yard 37″ measure which if multiplied by the length of the web gives the total number of shots in the web and this number multiplied by the reed width in inches and divided by 36 (inches in 1 yd.) equals the total length in yards of the weft in the complete web. Consequently if this length be divided by the number of yards per bundle or lb., the quotient equals the length in bundles or weight in lbs. respectively of the weft in the whole web, to which must be added the amount allowed for waste.

The foregoing may be simplified and expressed as follows :—

Formula for finding the quantity of weft in a web of 37″ measure for 37″ glass.

$$a = \frac{\text{Shots per glass} \times 200 \times \text{length of web} \times \text{reed width}}{\text{Yards per bundle} \times 36\text{″ per yard}} = \text{bundles}$$

$$\text{Plus waste} = \text{bundles} \times \frac{100 + \%\ \text{waste.}}{100}$$

$$b = \frac{\text{Shots per glass} \times 200 \times \text{reed width} \times \text{length}}{\text{Yards per lb.} \times 36\text{″ per yard}} = \text{weight in lbs.}$$

$$\text{or} \quad \frac{\text{Number of bundles} \times \text{cuts per bundle}}{\text{Cuts per lb.}} = \text{weight in lbs.}$$

Note.—If the cloth is measured 36″ to the yard then the formula would read.

$$a^1 \quad \frac{\text{Shots per glass} \times 200 \times \text{reed width} \times \text{length}}{37 \times \text{yards per bundle}} = \text{No. of bundles.}$$

$$\text{Plus waste} = \text{bundles} \times \frac{100 + \%}{100}$$

$$b^1 \quad \frac{\text{Shots per glass} \times 200 \times \text{reed width} \times \text{length}}{37 \times \text{yards per lb.}} = \text{weight in lbs.}$$

Then applying the foregoing formula the quantity and weight of the weft would be :—

$$(1) \quad \frac{12 \times 200 \times 75 \times 40}{60{,}000 \times 36} = 3\tfrac{1}{3} \text{ bundles.}$$

$$\text{Plus waste} = \frac{10}{3} \times \frac{105}{100} = 3\tfrac{1}{2} \text{ bundles.}$$

$$(2) \quad \therefore \text{ Weight in lbs.} = \frac{7}{2} \times \frac{200}{40} = 17\tfrac{1}{2} \text{ lbs. including waste.}$$

$$\text{or} \quad \frac{12 \times 200 \times 40 \times 75 \times 105}{300 \times 40 \times 36 \times 100} = 17\tfrac{1}{2} \text{ lbs.}$$

Relative Quantities and Weight of Warp and Weft in Fancy Woven Fabrics.

In the production of fancy woven fabrics, in which there are several colours or different sorts of warp and weft introduced, it is essential to ascertain the weight of each sort of warp and weft, and in the case of the warp the respective number of ends of each colour and sorts, so that the several warps can be ordered and made to the required number of ends.

The method of determining these factors will be best understood by a consideration of the following examples.

Example 1.—A 2/36 worsted warp containing 2880 ends is 70 yards long, and warped to pattern as follows :—

2 threads dark brown
2 threads dark blue } 16 threads.

2 threads dark brown
2 threads slate } 8 threads.

24 threads in each repeat of the pattern.

Then it is evident that

$$\frac{\text{Total number of ends in warp}}{\text{Threads in 1 repeat of pattern}} = \text{No. of repeats of pattern in warp.}$$

and, number of repeats × ends in each repeat of any colour = number of ends of given colour.

Formula XXIII.

$$\frac{\text{Total No. of threads in warp} \times \text{threads in each repeat of any colour}}{\text{Total number of threads in one repeat of pattern}} = \text{the number of threads of colour in warp.}$$

Then, since there are

12 threads of dark brown in each repeat of pattern
and 8 ,, dark blue ,, ,, ,,
and 4 ,, slate ,, ,, ,,

(1) Dark brown $= \frac{2880 \times 12}{24} = 1440$ ends.

(2) Dark blue $= \frac{2880 \times 8}{24} = 960$ ends.

(3) Slate $= \frac{2880 \times 4}{24} = 480$ ends.

The weight of each sort may be found by the ordinary method thus :—

(1) Dark brown $= \frac{1440 \times 70}{560 \times 18} = 10$ lbs.

(2) Dark blue $= \frac{960 \times 70}{560 \times 18} = 6\frac{2}{3}$ lbs.

(3) Slate $= \frac{480 \times 70}{560 \times 18} = 3\frac{1}{3}$ lbs.

Example 2.—

A fancy worsted is warped and woven

3 threads dark steel 1 thread light steel 1 thread dark steel 3 threads light steel	40 threads.
2 threads dark steel 1 thread light steel 1 thread dark steel 1 thread light steel 1 thread dark steel 2 threads light steel	48 threads.

88 threads in each repeat of the pattern.

If the Set is 19s reed 4s and 64″ wide, 70 yards of warp of 30s Y. S. woollen, find the number of ends of warp and weight of each colour of warp and weft. The length of warp to be taken to cover the waste of weft when calculating the weight of weft, 72 picks per inch of 30 skeins woollen.

In each repeat of the pattern it will be noted that there are 44 threads each of the dark and light steel.

Then 19s reed 4s = 76 threads.

and 76×64 = total number of threads in warp.

∴ By formula XXIII.,

$$\frac{76 \times 64 \times 44}{88} = 2432 \text{ threads of dark steel.}$$

do. = 2432 ,, light ,,

Then weight of dark steel =

$$\frac{2432 \times 70}{30 \times 256} = 22\tfrac{1}{6} \text{ lbs.}$$

and weight of light steel = $22\frac{1}{6}$ lbs.

Total = $44\frac{1}{3}$ lbs. of warp.

Weight of dark colour of weft.

$$= \frac{72 \times 64 \times 70 \times 44}{30 \times 256 \times 88} = 21 \text{ lbs.}$$

and weight of light colour of weft = 21 lbs.

Total = 42 lbs. of weft.

Example 3.—A vesting fabric is made to the following particulars :—

Face warp 2/48s black worsted.
Back ,, 2/48s black cotton.
,, ,, 2/48s light green worsted.
,, ,, 24/2 spun silk, red.

The red silk and light green worsted are used in place of the cotton threads at the back of the cloth, and brought to the face for spotting effects where required.

Face weft 2/44 black worsted.
Back ,, 2/48 black cotton.
Reed width 62 inches, length of warp 70 yards.

Length of cloth grey 66 yards, add 5% for waste of weft in weaving. Find the weight of each sort of warp and weft, and the number of threads of each colour of back warp. The texture is warped and woven one end and pick of warp and weft respectively. The order of the backing warp is as follows :—

1 thread of black cotton
2 threads of red silk
7 threads of black cotton
3 threads of light green worsted
2 threads of red silk
3 threads of light green worsted
6 threads of black cotton

24 threads in each repeat of backing warp.

SUMMARY—

14 threads of black cotton
4 threads of red silk
6 threads of light green worsted

24 threads

Then, since the warp and weft threads are end and end and pick and pick respectively, and since there are 112 ends and 96 picks per inch respectively, the number of ends and picks of face and back are 56 and 48 respectively.

(1) Then the number of ends of face

$$= 56 \times 62 = 3472$$

(2) The weight of face warp

$$= \frac{56 \times 62 \times 70}{24 \times 560} = 18\tfrac{1}{12} \text{ lbs.}$$

In this example it is better to find the number of patterns or repeats in the full width of the warp, then to multiply the complete number of repeats by the number of ends in each repeat of the pattern, and add the number of ends of each respective colour in the last fraction of a repeat. If the pattern is very large, it is sometimes possible to arrange the beginning and ending of the warping plan so as to save a relative number of the more expensive threads without in any way deteriorating the effect of the cloth.

$$\frac{3472}{24} = 144 \text{ repeats plus } 16 \text{ threads.}$$

(3) The number of ends of black cotton,

$$= 144 \times 14 + 8 \quad = 2024$$

(4) Of red silk,

$$= 144 \times 4 + 4 \quad = 580$$

(5) Of light green worsted,

$$= 144 \times 6 + 4 \quad = \underline{868}$$

Total number of backing threads=3472

(6) Weight of 2/48s black backing cotton

$$= \frac{2024 \times 70}{24 \times 840} = 7 \text{ lbs.}$$

(7) Of 24/2 spun silk, red—(back)

$$= \frac{580 \times 70}{24 \times 840} = 2 \text{ lbs.}$$

(8) Of 2/48s light green worsted (back)

$$= \frac{868 \times 70}{24 \times 560} = 4\tfrac{1}{2} \text{ lbs.}$$

(9) Weight of face weft

$$= \frac{48 \times 62 \times 66}{24 \times 560} \times \frac{105}{100} = 15\tfrac{1}{3} \text{ lbs.}$$

(10) Weight of back weft

$$= \frac{48 \times 62 \times 66}{24 \times 840} \times \frac{105}{100} = 10\tfrac{1}{4} \text{ lbs.}$$

Example 4.—Given the order as below for a striped pattern, 40s linen warp, show how the warp must be put on 4 warping beams so that the pattern will be in regular order on the dressing machine and weaver's beam. Also give the number of threads and weight of each colour of warp when the length is 360 yards and to be woven in a 12°° reed.

(1) The foregoing, reading down each column, is summarised as follows :—

Warper's beams 1 and 2; 3 ends white, 4 ends red, 1 white.
,, ,, 3 and 4; 1 white 1 blk. 1 white 1 red 1 blue 1 red 1 white 1 blk.

NOTE.—The warp beams must always be arranged in the same order as the draft so as to correspond with it.

PATTERN.	WARP BEAM NUMBER. 1	3	2	4 Linen draft
	1	2	3	4 Straight ,,
6 ends white	2	2	1	1
2 ,, black			1	1
4 ,, white	1	1	1	1
6 ,, red	2	2	1	1
2 ,, blue			1	1
6 ,, red	2	2	1	1
4 ,, white ...			1	1
	1	1		
2 ,, black			1	1

32 threads in repeat = 8 + 8 + 8 + 8

(2) No. of threads of each colour of warp =

(a) White, $\frac{2400 \text{ ends in warp} \times (14 \text{ ends of white in 1 repeat})}{32 \text{ ends of white warp in 1 repeat}} = 1050$

(b) Black, $\frac{2400 \times (4 \text{ ends in one repeat})}{32} = 300$

(c) Red $\frac{2400 \times (12 \text{ ends in one repeat})}{32} = 900$

(d) Blue, $\frac{2400 \times (2 \text{ ends in one repeat})}{32} = 150$

2400

(3) (a) Weight of white warp $= \frac{1050 \times 360}{40 \times 300} = 31{\cdot}5$ lbs.

(b) ,, black ,, $= \frac{300 \times 360}{40 \times 300} = 9$,,

(c) ,, red ,, $= \frac{900 \times 360}{40 \times 300} =$ 27 ,,

(d) ,, blue ,, $= \frac{150 \times 360}{40 \times 300} =$ 4·5 ,,

Total weight of warp = 72 lbs.

When the colour scheme is of large repeat it will be found more convenient and expeditious to write out the warping and weaving plan something after the following order, since the summary of threads of each colour may be much easier obtained than by the ordinary and previous arrangements.

Example 5.—A Tartan is made from 2/24s worsted warp and weft 12s reed 4s and 44 picks per inch. Width in reed is 32 inches exclusive of edges. The length of warp to cover the waste of weft in weaving. The order of warping and wefting is as given below. Find the number of ends of each colour of warp and the weight of each colour of warp and weft.

Shade.	Threads of each colour in one repeat.
Black,	8, 4, 16, 4, 4, 4, 4, 16, 4, 16, 4, 4, 8=96
Light green,	16, 16, 16, 16, =64
Navy blue,	4, 4, 16, 4, 4, 16, 4, 16 =68

Total number of threads in each repeat = 228

Then,

(1) The total number of threads in warp exclusive of edges = 32 × 48 = 1536.

(2) The number of repeats of pattern in full width of piece $= \frac{1536}{228} =$ 6 repeats of pattern + 168 ends.

And to find the number of threads of each colour in the remaining portion of pattern, the designer should

then mark off the portion of repeat of pattern (168 threads and then total up the number of threads of each colour in this portion of repeat of pattern. These threads can then be added to their respective colours of warp as below :—

(3) Then the No. of ends of black = 6 repeats of pattern + 72 ends
$= (96 \times 6) + 72 =$ 648

(4) ,, ,, light green = 7 repeats of pattern
$= 64 \times 7 =$ 448

(5) ,, ,, navy blue = 6 repeats of pattern + 32 ends
$= (68 \times 6) + 32 =$ 440

Total number of ends in warp = 1536

In patterns of large repeat it is frequently advisable to commence the colour scheme so that each side of the piece will be as much alike as possible. In this example, the pattern has purposely been started with 8 threads of black and finished with the same number and colour of threads, in addition to which, it should be noted that the other colours on the opposite sides of the cloth also balance each other.

Then the weight of the respective colours of warp and weft are :—

(6) Black warp $= \frac{648 \times 70}{560 \times 12} = 6\frac{3}{4}$ lbs.

(7) Light green warp $= \frac{448 \times 70}{560 \times 12} = 4\frac{2}{3}$ lbs.

(8) Navy blue warp $= \frac{440 \times 70}{560 \times 12} = 4\frac{7}{12}$ lbs.

The weight of each colour of weft may be found separately as before, or the total weight can be first obtained and then proportions of weight deter-

mined by the ratio of picks of each colour to the total number of picks in each repeat, thus :—

(9) The total weight of weft including lists (32 + 1) 33 inches

$$= \frac{44 \times 33 \times 70}{560 \times 20} = 9 \text{ lbs.}$$

(10) Weight of black weft $= \frac{9 \times 96}{228} = 3{\cdot}8$ lbs.

(11) ,, light green ,, $= \frac{9 \times 64}{228} = 2{\cdot}5$ lbs.

(12) ,, navy blue ,, $= \frac{9 \times 68}{228} = 2{\cdot}7$ lbs.

Total 9 lbs.

EXERCISES.

General.

1. A warp is required to weigh 35 lbs. and contain 1800 ends. There must be 2 threads of 2/48s cotton to 1 thread of 2/24s worsted. What weight of each sort will be required, and what will be the length of the warp ?

Ans., 14 ; 21 ; 235·2.

2. A union is made from 32s cotton warp laid 100 yards and in a 12°° reed, 40″ scale 30 inches in the reed 13 shots on 37″ glass of 50s lea yarn. Find the total weight of the warp and of the weft, if 90 yds. of 36″ cloth is produced.

Ans., 6 lbs. 11 ozs. ; 12 lbs. 10 ozs.

3. A 10/6 union cloth is made from 22s line, 100 yds. warp laid 30″ in reed, giving 90 yds. of cloth. What number of cotton should be used as weft to make quantities of cotton and linen equal in weight ?

Ans., 4·7.

4. Given a union cloth of which the warp is 200 yards long producing 175 yds. of cloth (37″ per yd.) 36 inches wide, 40

inch reed space. Warp 60s cotton made in 600 reed 40″ scale and woven 4 shots to 37″ glass. Find the lea of the weft, when the weight of warp and weft are equal.

Ans., 108·9.

5. A union is made from 16s cotton warp laid 100 yards, 60 ends per inch, 30″ reed width, 13 shots on 37″ glass of 50s linen yarn. Find total weight of warp and weft, if 90 yds (36″) cloth is produced.

Ans., 10·4 ; 12·65.

Woollen and Worsted.

6. A dyed woollen cloth is made from 2/32 Y. S. warp 16 reed 3s, 70 inches wide, 15 skeins woollen weft, 44 picks per inch ; length of warp, 80 yards ; piece out of loom, 72 yards ; allow 5% for waste of weft in weaving. Find the weight of warp and weft.

Ans., $65\frac{5}{8}$; $60\frac{5}{8}$.

7. A Union Coating is made from 70 yards of warp of 2/30s cotton, 72 Set Bradford ; 68 inches reed width ; 88 picks per inch of 1/36s Botany weft ; length of piece out of loom, 68 yards. Required the weight of warp and weft. Add 5% to cover waste of weft.

Ans., $30\frac{2}{5}$; $21\frac{1}{5}$.

8. Given 540 hanks of 20s worsted, it is required to weave this lot up with a warp 64 inches wide, and the cloth is to contain 75 picks per inch. What length of piece will this number of hanks produce, exclusive of any loss of waste in weaving.

Ans., 63.

9. 120 hanks of worsted have to be woven into a cloth 40 yards long. The width in the reed is 32 inches. What number of picks per inch will the cloth contain ?

Ans., $52\frac{1}{2}$.

10. The length of a warp is 70 yards ; length of piece 60 yds. ; reed width 63 inches ; 64 ends 2/48s worsted ; 64 picks per inch of 20s worsted. Find the weight of warp and weft ; add 5% to weight of weft for waste in weaving.

Ans., 21 ; $22\frac{17}{25}$.

11. A warp is required to be made of two threads of 2/60s worsted to one thread of 2/40s worsted. Length of warp 300 yards, weight of material 50 lbs. What number of ends and what weight of each sort will be required ?

Ans., 1600 ; 800 ; $28\frac{4}{7}$; $21\frac{3}{7}$.

12. A Scotch Tweed double cloth is produced from 34 cut warp, and 33 cut weft (Gala.). The cloth is woven with 84 ends and picks per inch, 68 inches reed width. The length of warp is 80 yards, and that of the piece 70 yards. Add 5% for waste of weft in weaving. Find the respective number of ends of warp and weight of each colour of warp and weft when the warping and weaving scheme of colouring is as given herewith.

8	threads	dark brown	
2	,,	white	for 72 threads
2	,,	brown and white	
4	,,	dark brown	
4	,,	white	for 24 threads.
4	,,	brown and white twist	
4	,,	dark brown	
4	,,	white	
2	,,	brown and white twist	
2	,,	red and white twist	
4	,,	dark brown	
4	,,	white	60 threads.
4	,,	brown and white twist	

Ans., 5712 ; 67·2 ; 63·6.

13. A worsted costume cloth is made from 2/36s warp and weft. It contains 44 ends of warp and 40 picks per inch. Length of warp 70 yards ; width in reed 64 inches ; length of piece 63 yards ; warped and woven as follows :—

2	threads	black
1	thread	white
1	,,	black
2	threads	white
1	thread	black
1	,,	white

Find the weight of each colour of warp and weft, and the ends of each colour of warp.

Ans., $9\frac{7}{9}$ lbs. of each warp ; 8 lbs. of each weft ; 1408 ends each.

14. A heavy fancy worsted is composed of 2/28 worsted warp and weft. It contains 92 ends and 84 picks per inch ; reed width 66 inches. Length of warp 75 yards, which length is to be also taken to cover the waste of weft in weaving. Find the number of ends of each colour of warp, and weight together with the respective weights of warps and wefts, when the warp and weft plan is as follows :—

16 threads dark smoke
16 ,, light ,,
} for 128 threads.

12 ,, dark ,,
12 ,, light ,,
} for 96 threads.

Ans., 6072 ; 58 ; 53.

15. A vicuna cloth is composed of 2/48s worsted warp for face and back. Face weft 1/24s worsted, back weft 20 skeins woollen, woven 2 ends and picks of face to 1 end and pick of back. 16s reed 6s ; 75 inches reed width ; finished 56 inches ; 96 picks per inch ; face warp 66 yards ; back warp 73 yards ; 63 yards out of loom ; allow 5% for waste of weft in weaving. Find weight of each warp and weft.

Ans., $23\frac{4}{7}$; $23\frac{5}{8}$; $13\frac{1}{2\frac{5}{8}}$; 31.

16. A double cloth is composed of 2 ends and picks of face to 1 end and pick of back. It is made from 2/28s worsted, and 16 skeins woollen ; length of warp 70 yards ; reed width 64 inches ; 72 ends and 68 picks per inch ; length of piece out of loom, 63 yards. The warping and wefting plan is as follows :

4 threads black
4 threads slate
} 24 threads
2 threads black
2 threads slate
} 24 threads
} Face.

2 threads black
2 threads slate
} 12 threads
1 thread black
1 thread slate
} 12 threads
} Back.

Find the number of ends of each colour of warp, and weight of each sort and shade of warp and weft. Add 5% to weight of weft for waste in weaving.

Ans., 3072 ; $27\frac{3}{7}$; $24\frac{1}{2}$; 1536 ; $26\frac{1}{4}$; $23\frac{2}{5}$

17. The weight of a warp is 49 lbs. ; it must contain 60 ends of worsted for face, and 30 ends of cotton for back ; width in reed 63 inches ; length of face warp to be 120 yards, and that of back warp 108 yards. The relative weight of the former to the latter is as 4 to 3. Find the counts of each warp.

Ans., 29 ; $11\frac{1}{7}$.

NOTE.—In all questions warped and woven to pattern, the answers are only given for the TOTAL number of ends and weights of warp and weft, which totals, the SUM of the respective proportions should equal.

COTTON AND SILK.

18. A cotton cloth is made from 80 yards of warp of 2/80s cotton, 40 inches wide in the reed ; $66\frac{2}{3}$ ends per inch ; 15 picks per $\frac{1}{4}$ inch of 1/40s cotton. What weight of warp and weft is required exclusive of any sizing substance. 5% to be added to the weight of weft to cover waste ; length of piece 75 yards.

Ans., $6\frac{7}{20}$; $5\frac{5}{8}$.

19. What counts of cotton weft will be required in the production of the following cloth ? Weight of piece (70 yards) including 100% of sizing material, is $16\frac{1}{2}$ lbs. Warp 1/34s cotton ; 75 yards of warp ; 48 ends per inch ; 38 inches wide, and 40 picks of weft per inch.

Ans., 36^3

20. A cotton tapestry is made of 1 thread 3/2/30 cotton, and 1 thread 2/100 cotton ; 30s reed 2s ; 60 inches reed width ; length of thick warp 70 yards, of fine warp 90 yards ; length of piece 65 yards.

Weft 1 pick 2/30s cotton
1 ,, 1/4s ,, soft twist dark green } 72 picks per inch.
1 ,, 1/4s ,, ,, light ,, }

Add 5% for waste of weft in weaving. Supply the weight

and number of ends of each sort of warp, and weight of each kind of weft.

Ans., 30 ; $3\frac{6}{7}$; 1800 ; $7\frac{1}{5}$; $29\frac{1}{4}$.

21. Calculate the quantities of Terry pile and ground warps and weft in 300 yards of Terry cloth woven in a reed $19\frac{1}{2}$ ins. wide as follows :—ground warp 594 ends of 18s twist, contraction of warp in cloth equals 7% ; Terry warp 528 ends as pattern given below ; the length of Terry warp is $3\frac{1}{2}$ times that of the ground. The woven cloth contains 44 picks per inch of 18s cotton weft.

Terry warp pattern—

3/18s grey	10	—	192	—	=	202	264
3/20s blue	8	8	8	8	=	32	
2/12s bleached	10	—	10	10	=	30	

Ans., 12·67 ; 90·5 ; 12·9 ; 13·44 ; 17 lbs.

Linen, Jute, etc.

22. Evolve a simple equivalent which when multiplied by the number of shots counted under a $\frac{37}{200}$″ glass is equal to the number of shots per inch.

Ans., 5·4.

23. A cloth counts 76 ends per inch, how many threads would it count under (a) the Spanish, (b) the French, (c) the 37 inches glass.

Ans., 14·97 ; 17·94 ; 14·06.

24. Find weight of weft in 90 yards of 24″ huckaback ; weft $2\frac{1}{2}$ lbs. flax ; loss in bleaching 15% ; 8 shots per 37″ glass, allow 10% for shrinkage.

Ans., 15 lbs. 11 ozs.

25. Give the quantities, in bundles, separately, of warp and weft in a web 38 ins. wide, 85 yds. long, made in a reed 1000 dents on 40 ins., with two warp threads in each dent, and counting 12 shots of weft to 37 ins. glass ; allowing 3% for shrinkage in the length of warp and 3% for shrinkage in width in reed.

Ans., 3·19 ; 3·59.

26. Find the number of bundles of weft that would be required to make 12 pieces with 18 shots of weft on 37″ glass.

Width of warp in reed 39″ ; length of each web per 37″ yard equals 70 yards.

Ans., 54 bundles ; 120 cuts.

27. Find the quantity of warp and weft in bundles required to make 4 webs of 12/14 (12°° reed × 14 shots) warp laid 80 yards. Reed width 40 inches, 40″ scale and 37″ glass, length of 37″ web is 72 yards. Add 2½% to warp and 5% to weft to cover waste in preparation and weaving.

Ans., 13·12 ; 15·68.

28. Given 12°° reed, 37″ scale, how many warp threads should be laid over 40″ reed and how many bundles of lea yarn would be required to produce 90 yards of warp ?

Ans., 2595 ; 3·8925.

29. Find the amount of linen and cotton in bundles and lbs. respectively in a web of checked glass cloth 24″ wide, 90 yards long (36″) made in 10°° reed on 40″ scale—12 shots to 37″ glass of 35s lea weft. Allow 10% for shrinkage in length and 5% shrinkage in width. The cotton is 2/24s.

Warp pattern 40 threads of linen, 2 threads of cotton.

Weft ,, 50 ,, ,, 2 ,, ,,

Ans., 4·36 bundles ; 1·15 lbs.

30. Calculate the net quantity in bundles of warp and weft in one web of 72″ fine damask, bleached, 100 warp threads and 150 weft shots per inch in the finished state ; warp length 50 yds. ; length of cloth 48 yds. ; contraction from reed to finished width 7%. Find the weight of the cloth per square yard finished when warp is 55s line and weft 80s line both creamed and estimated to lose 25% in creaming and subsequent bleaching.

Ans., 6 ; 9·3., 5·6 ozs.

31. A sheeting made from 14s and 16s, set 7 × 8, warp laid 80 yards, produces 66 yards of cloth, after bleaching and finishing the length is 74 yards. Find percentage " outcome."

Ans., 12⅛%

32. A 36 inches grey linen, counting 47/54 per inch, is wanted to weigh about 26½ lbs. per 100 yards. What count of yarns should be used ?

Ans., 46·8 or 45/50s.

33. Calculate the counts of warp and weft which would be required to weave a linen web 90 yards long (37″) 38″ wide and weighing 23 lbs., set 50 × 60 ends per inch in the cloth ; assume that there will be 12 per cent. contraction in the length and 5 per cent. shrinkage in the width.

Ans., Av. 60s, or 55/65s.

34. A standard 38″ brown linen web 90 yards long, 37″ measure is made from a warp 100 yards in length set 40″ in the reed and woven with 15 shots per $\frac{37}{100}$″ glass. (a) Reduce all the constant factors in this and like problems to a simple equivalent ; (b) Using this simple equivalent together with the remaining but changeable factors ascertain the quantity in bundles of weft required for the above web ; (c) formulate a table of bundles required for every web containing shots from 10 to 20 inclusive ; (d) state what quantity in bundles will be required for each additional shot of weft in this and like webs of length and width.

Ans., (a) $\frac{1}{2\frac{1}{70}}$; (b) 5 ; (c) $3\frac{1}{3}$, $3\frac{2}{3}$, 4, $4\frac{1}{3}$, $4\frac{2}{3}$, 5, $5\frac{1}{3}$, $5\frac{2}{3}$, 6, $6\frac{1}{3}$, $6\frac{2}{3}$; (d) $\frac{1}{3}$.

CHAPTER XI.

The Weight and Cost of Woven Fabrics.

In the production of woven textures, the actual cost must as far as possible be determined in order that the manufacturer may know at what price his production can be sold so as to leave a working profit.

Profits depend largely on the amount allowed for depreciation. The surest way of reducing costs to a minimum is to first ascertain the cost, otherwise the producer, manufacturer or merchant may be selling at a loss and not only destroy his own business, but unwittingly injure the trade of his competitors.

In the buying and selling of fabrics, the quality, width, price and weight per yard are usually specified. To arrive at the actual cost and weight per yard, a consideration of the following particulars is involved.

(1) The weight and cost of warp.
(2) The weight and cost of weft.
(3) The preparatory cost of warping, sleying, dressing, drawing in, twisting, tying in and final sleying.
(4) The relative cost of wear and tear of gears or harness and reeds.
(5) The cost of weaving, including winding of the weft when necessary.
(6) The cost of burling and mending, if any.
(7) The proportionate cost on each piece, of the management and administrative staff, foremen, overlookers, tuners or tenters, passers and assistants and all other datal employees.
(8) Productive capacity and efficiency of machines and employees.

(9) Interest or rent to be charged per loom per week for interest or depreciation or renewals and insurance on capital expended on the building, equipment and plant.
(10) The waste of warp and weft in the preparation and weaving.
(11) The loss of weight in scouring and finishing.
(12) The shrinkage in width and length, or other variation.
(13) The cost of dyeing and finishing.
(14) The 'over'-measure to customers.
(15) The percentage in commission to salesmen, agents, and travelling expenses.

The operation of finding the weight and cost of warp and weft is in reality a simple process to the student and manufacturer who has studied the previous chapters; the methods explained and adopted in relation thereto admit of general application. But the mode of appropriating the incidental or departmental costings to each piece or yard of cloth produced, varies essentially with the kind of material made, and incidentally in method and detail with the locality and manufacturer.

Generally, the incidental expenses connected with the production of woven structures are carefully noted upon a 5 or 6-cut warp for worsted, and about a 10-cut warp for dress or cotton goods. The average cost per piece is then struck for 1 cut, which is usually found to be about twice the amount of the actual price paid for weaving. It will thus be seen that three times the cost of weaving covers the cost of production, and to this must be added the cost of dyeing and finishing, and an allowance for commission to agents and salesmen. In the latter case 5% is added to the

actual cost for plain and dyed goods, but for fancies, about $7\frac{1}{2}\%$ is considered necessary.

A few of the varying factors may here be pointed out to illustrate some of the difficulties which appear at every attempt to formulate a scheme that will admit of general application in every detail. The payment to the weaver, though generally reckoned at some fixed price per number of picks in a $\frac{1}{4}$, $\frac{1}{2}$, or 1 inch for some definite and standard length of warp, also varies with the kind and width of loom, *e.g.*, whether plain, drop box, circular box, odd or even pick, and the number of colours of weft. Further, the warp threads may be drawn through a set of gears containing 4, 8, 16 or more heald shafts, which, as they increase in number, increase the difficulty in production, especially with harness mountings. The sets may also vary in fineness, while some warps weave much better than others, and thus the latter retard the output for the same datal expenses. Again, the length of the warp is sometimes very short (1 cut) which also adds to the relative cost in making a piece. All things considered, it will be best to find some approximate multiple of the weaving wage which will cover the incidental expenses in the cost of making some standard cloth, and afterwards add or deduct any extraordinary expenses or savings on any special type of cloth. If a customer has a large order to place at a lower price than the manufacturer's quotation, it is advisable then for the latter to enter most thoroughly into the details of all incidental expenses so as to ascertain whether it be possible to effect a reduction in any of the miscellaneous items specified in the costing book.

The following progressive examples will clearly demonstrate the principles and method of finding the weight and cost of fabrics :—

Example 1.—Find the average cost per web in weaving a 5-cut warp, 350 yards long, and containing 5280 ends, 18 picks per $\frac{1}{4}$ inch, at 1/2 per $\frac{1}{4}$ pick for weaving 70 yards of warp, the departmental expenses being as given herewith :—

Incidental and datal expenses.	Total cost for full warp. £ s. d.	Proportionate cost per web. £ s. d.
1. Cost of sleying and dressing, at 10d. per 1000 ends for sleying and starting, and 4/2 per cut of 70 yards for running warp on to beam	1 5 2	0 5 1
2. Cost of twisting in at 1/- per 1000 ends	0 5 3	0 1 1
3. Wear and tear of gears and reed ...	0 12 6	0 2 6
4. Proportionate cost of management, administration and datal employees...		0 10 0
5. Burling and mending		0 11 0
6. Loom, interest and depreciation of capital, buildings, engines and boilers		0 10 0
7. Cost of weaving 18 picks at 1/2 ...		1 1 0
Average cost per cut		£3 0 8

Or, approximately, three times the weaving wages, leaving about twice the weaving wage for incidental expenses.

Example 2.—Find the cost per yard of a finished worsted coating, 58 yards long, 56 inches finished, made as follows :—Warp 70 yards, 2/36s Botany at 5/- per lb., 20s reed 4s, 66″ reed width ; weft 19 picks per $\frac{1}{4}$ inch, 1/18s Botany at 4/10 per lb.; 63 yards of cloth out of loom. Cost of weaving 1/2 per $\frac{1}{4}$ pick ;

departmental expenses twice the cost of weaving; allow 5% for commission; length of warp to cover the cost of waste of weft in weaving. Dyeing and finishing, Indigo blue, 78/-. Allow the usual 37 inches per yard, and 1 yard over-measure.

Thus for warp by formula XXI. and price per lb.

$$\frac{\text{Ends per inch} \times \text{inches wide} \times \text{length of warp}}{\text{Yards per lb.}} \times \text{price per lb.} = \text{cost of warp.}$$

And for weft, by formula XXII. and price per lb.

$$\frac{\text{Picks in in.} \times \text{ins. wide} \times \text{lgh. of piece} \times 100 + \%\text{ for waste}}{\text{Yards per lb.} \times 100} \times \text{price per lb.} = \text{cost of weft.}$$

In this example the length of the warp is taken to cover the waste of weft in weaving.

Then cost of warp

			s.	d.
(1)	$= \frac{80 \times 66 \times 70 \times 5}{18 \times 560}$	=	183	4

The cost of weft

(2)	$= \frac{76 \times 66 \times 70 \times 58}{18 \times 560 \times 12}$	=	168	4

Cost of weaving

(3)	= 19 picks at 1/2	=	22	2

Incidental expenses

(4)	= Twice weaving	=	44	4
(5)	Dyeing and finishing	=	78	0
			496	2
(6)	5% for commission, etc. = 496 × 5% = 24·80	=	24	10
		Total cost	521	0

(7) Then 58 yards less $\frac{1}{37}$ or converted into yards of 37 inches $= \frac{58 \times 36}{37} = 56\frac{16}{37}$ yards and $56\frac{16}{37}$ yards $-$ 1 yard over-measure $= 55\frac{16}{37}$ yards for which payment is received.

$\therefore$ Cost $= \frac{52\text{1s. } 0\text{d.}}{55\frac{16}{37}} = 9/3$ per yard.

Example 3.—Find the weight and cost per yard of a fabric which is made from 2/48s Botany at 6/- per lb., woven in a 90 Set Bradford, 66 inches reed width, 70 yards of warp, 63 yards of cloth out of loom, 56 yards (37″) finished ; weft 1/26s Botany, 120 picks per inch at 5/8 per lb., add 5% to weight of weft for waste in weaving. Cost of weaving, 1/2 per $\frac{1}{4}$ pick. Incidental expenses twice the cost of weaving. Dyeing black and finishing 46/-. Add 5% to total cost for allowances, commission, etc. Allow 1 yard over-measure. Loss of weight in scouring and finishing is neutralised by increased weight of the dyewares.

NOTE.—In the solution of such questions as above, it is better to keep both weights and costs separate so that the weight and cost per yard can be more readily obtained, thus :—

Weight and cost of warp

By formula XXI. Weight in lbs. $\times$ Cost in shillings.

(1) $\frac{90}{36} \times \frac{40}{24} \times \frac{66 \times 70}{560} = 34\frac{3}{8} \times 6/- = 206\ 3$

(2) Weight and cost of weft,

By formula XXII.

$$\left.\begin{array}{ll} \frac{120 \times 66 \times 63}{26 \times 560} & = 34\frac{1}{4} \\ \text{Plus waste in weft.} & \\ 34\frac{1}{4} \times 5\% & = 1\frac{3}{4} \end{array}\right\} \times 5/8 = 204\ 0$$

(3) Cost of weaving 30 picks per $\frac{1}{4}$, at 1/2 =		35	0
(4) Incidental expenses, twice the weaving wage	=	70	0
(5) Dyeing and Finishing	=	46	0
	Actual cost	561	3
(6) Add 5% for allowances, commission, etc. = 280s. $7\frac{1}{2}$d. × 5% =		28	0
	Total cost	589	3

And 56—1 yard for over-measure=55 yards.

$$\therefore \frac{589\text{s. } 3\text{d.}}{55} = 10/9 \text{ price per yard.}$$

Calculated weight of warp = $34\frac{3}{8}$ lbs.

,, ,, weft = $34\frac{1}{4}$ lbs.

$68\frac{5}{8}$ lbs.

$$\therefore \text{Weight per yd.(37")} \text{ of cloth} = \frac{68\frac{5}{8} \times 16}{56} = 19/20 \text{ ozs.}$$

Costing of Dress Goods.

In the manufacture of dress goods and linings, the prices paid for weaving vary from 4d. to 9d. per $\frac{1}{4}$ pick, for a unit length of warp of 70 yards, these prices being for plain and box looms whose reed space varies from 36 to 76 inches.

The woven fabrics are delivered to the merchant both in the grey and finished as circumstances may demand. For pieces delivered in the grey, the incidental expenses generally average from $1\frac{1}{4}$ to $1\frac{1}{2}$ times the cost of weaving for all cloths woven on the ' square ' or approximately so, and containing not

less than 15 picks per $\frac{1}{4}$ inch. When the pieces are delivered in the finished state, the incidental expenses vary from $1\frac{1}{4}$ to $1\frac{3}{4}$ times the weaving wage, to which must be added the cost of dyeing and finishing, or finishing only.

In finding the cost of production of dress fabrics, as in most other types of cloth, extraordinary circumstances arise for consideration, and any attempt to supply the multitudinous details for the great variety and types of cloth requires an amount of space which, in such a treatise as this, is out of proportion to the value of the information detailed, more especially so, since the prices and other items of cost are constantly varying factors. *In this chapter, it is my purpose only to explain the fundamental principles which form the basis of costing cloths manufactured ready for sale.*

A very good method is to first determine the average cost per loom per week of all the datal and miscellaneous expenses. Then divide the cost of each loom thus obtained by the number of pieces which can be produced in any given quality in any given loom per week, or longer period, which would, of course, furnish the manufacturer with the cost per piece.

Example 4.—A plain *glacie* dress fabric is made as follows: 53 yards warp 2/100s cotton at 4/-, 50s set Bradford, 1/24s mohair weft at 6/4, 15 picks per $\frac{1}{4}$ inch, 31″ reed width, $30\frac{1}{4}$ inches grey, to finish 27 inches: 48 yards of cloth out of loom, to finish 50 yards. Find the weight of warp and weft, and cost of cloth grey when weaving costs $4\frac{1}{2}$d. per pick; add $1\frac{1}{2}$

times the cost of weaving to cover expenses, and 5% for waste of weft in weaving : add 5% commission for travelling expenses, freightage, etc.

		s.	d.
(1) Weight and cost of warp, $= \frac{50 \times 40 \times 31 \times 53}{36 \times 50 \times 840} = 2\frac{1}{6}$ lbs. at 4/- =		8	8
(2) Weight and cost of weft, $\frac{60 \times 31 \times 48 \times 105}{24 \times 560 \times 100} = 7$ lbs. at 6/4 =		44	4
(3) Paid for weaving, 15 picks at $4\frac{1}{2}$d.	=	5	$7\frac{1}{2}$
(4) Incidental Expenses, $5/7\frac{1}{2} \times 1\frac{1}{2}$	=	8	5
Cost	£3	7	$0\frac{1}{2}$
(5) Commission, freightage, etc., £3 7s. $0\frac{1}{2}$d. × 5 per cent	=	3	4
Total cost	£3	10	$4\frac{1}{2}$

Various Systems of Payment for Weaving Woollens.

In the woollen trade, as in other textile trades, the basis of payment for weaving has its methods and variations. In some localities the amount paid is reckoned at so much per stone on the calculation weight of the piece—warp and weft, which amount varies according to width of loom and thickness of warp and weft. In other districts the weaver is paid a fixed rate in pence per yard, warp length, based on 36 picks per inch with an increase or decrease in almost the same ratio according as the number of picks are more or less, some account being taken of the very thick weft which necessarily involves more

frequent changing of the shuttles. Another method is to pay a fixed price in pence per string, which is a variable factor from 9 to 10½ feet, usually 10 feet; and based on 10 or 40 picks per inch, for broad plain goods; other conditions being equal, the price varies in direct proportion to the number of picks put into the cloth. Whatever be the system adopted, they all eventually amount to a similar result, and further, in each case the incidental expenses add from 1½ to twice the price paid for weaving to the actual cost of the woven structure.

Example 5.—A dressed face fabric is composed of 2/36s cotton at 2/4 per lb., 15s reed 2s and 71 inches wide in the reed, length of warp 21 strings, 34 picks per inch of 10s pure woollen weft at 4/6 per lb.; cost of weaving, 7d. per string; cost of other items in production, 18/6; dyeing and finishing, 70/-; 68 yards (36 inches) of cloth out of loom, and 66 yards finished (37 inches per yard). Add 5% to weight of weft for waste in weaving, and 5% of total cost for commission, etc. Allow 10 per cent. for loss in scouring, raising, cutting and finishing. Find weight and cost per yard; allow 1 yard over-measure; 1 string equals 10 feet.

(1) Weight and cost of warp. s. d.

$$\frac{30 \times 71 \times 21 \times 10}{18 \times 840 \times 3} = 9\tfrac{5}{6} \text{ lbs. at } 2/4 \quad = 23 \quad 0$$

(2) Weight and cost of weft,

$$\frac{36 \times 71 \times 68}{10 \times 256} = 67\tfrac{7}{8} \Big\} \; 71\tfrac{1}{4} \text{ lbs. at } 4/6 \quad = 320 \quad 7\tfrac{1}{2}$$

Waste of weft $67\frac{7}{8} \times 5\% = 3\frac{2}{5}$

(3) Cost of weaving 21 strings at 7d.	=	12	3
(4) General expenses	=	18	6
(5) Cost of dyeing and finishing	=	70	0
Actual cost	=	444	$4\frac{1}{2}$
Commission, etc. 444s. at 5%	=	22	3
Total cost		466	$7\frac{1}{2}$

Calculation weight of warp and weft $= 77\frac{3}{4}$ lbs.

Loss in scouring and finishing, $77\frac{3}{4} \times 10\% = 7\frac{3}{4}$ lbs.

$\therefore$ Actual finished weight ... $= 70$ lbs.

Then weight per yard $= \frac{70 \times 16}{66} = 17$ ozs.

And $66 - 1 = 65$ yards for which payment is received.

$$\therefore \frac{466\text{s. } 7\frac{1}{2}\text{d.}}{65} = 7/2 \text{ per yard.}$$

Payment for Weaving Tapestries.

In the manufacture of tapestries, the payment for weaving necessarily varies very much on account of the enormous variety of woven structures produced. The following indicates the basis in its general outline for a six-quarter tapestry (52 inches finished) ; for 2 shuttles, 36 picks per inch, a fixed price in pence per yard is paid, with an addition or reduction per yard, for every 6 picks, within reasonable limits, above or below the standard of 36 picks, together with a very long list of extras for number of warp beams, shuttles, length of warp, tender warp, etc., all of which vary very considerably. The general expenses for each structure must be treated separately since the cost of designing, cards, cutting, etc., is sometimes

enormous, but is, of course, modified according to the number of pieces required of each design.

The price for finishing is usually reckoned at a small fixed sum per yard since the length of the pieces is so different. Pieces which contain silk usually require a dry finish and cost a few pence per yard, whilst worsted tapestries, which require a wet finish to enable them to 'set' properly, cost a fraction of a penny more per yard.

Example 6.—A tapestry fabric of compound structure is made as follows :—Warp, 21s reeds 7s ; 55 inches reed width ; 52 inches finished cloth, 68 yards out of loom (36 inches), and 64 yards finished (37 inches).

Warped :—

(a)	2	threads of	dark	green	2/56s	Botany	80 yds. at	5/8 per lb.
(b)	1	,,	light	,,	,,	,,	96 ,,	5/8 ,,
(a)	2	,,	dark	,,	,,	,,	80 ,,	5/8 ,,
(b)	1	,,	light	,,	,,	,,	96 ,,	5/8 ,,
(c)	1	,,	light	,,	2/48s	cotton	96 ,,	2/4 ,,

7 threads in 1 repeat of pattern.

Weft :—48 picks per inch.

Woven { 2 picks of 2/48s light green cotton at 2/4 per lb.
1 ,, 2s ,, ,, ,, 1/8 ,,

3 picks in one repeat of pattern.

Add 5 per cent. to weight of weft to cover waste in weaving ; cost 1/2 per yard on grey length ; cost of finishing 3d. per yard on finished length ; general expenses, including Jacquard cards 3/- per yard on finished length ; allow $7\frac{1}{2}$ per cent. on total cost for commission to agents, travelling expenses, etc. ; loss in scouring and finishing, 10 per cent. Find weight of

each sort of warp and weft, and weight and cost per yard of the tapestry, 37 inches per yard, and 1 yard over-measure.

Then, since there are 7 threads in each repeat of the warp pattern, and the number of threads of each sort of each repeat are 4 of dark green, 2 of light green (both Botany), and 1 of light green (cotton), the total number of ends of each sort in the whole warp are $\frac{4}{7}$, $\frac{2}{7}$, and $\frac{1}{7}$ respectively; and in the weft, $\frac{2}{3}$ of (2/48s) fine cotton and $\frac{1}{3}$ of (2s) thick cotton. If now the question be stated as heretofore and multiplied by the proportion of each respective sort, the total cost will readily be found, thus :—

(1) Weight and cost of dark green Botany, s. d.

$$= \frac{21 \times 7 \times 55 \times 80 \times 4}{28 \times 560 \times 7} = 23\tfrac{4}{7} \text{ lbs.} \times 5/8 \quad = 133 \quad 7$$

(2) Weight and cost of light green Botany,

$$= \frac{21 \times 7 \times 55 \times 96 \times 2}{28 \times 560 \times 7} = 14\tfrac{1}{7} \text{ lbs.} \times 5/8 \quad = 80 \quad 2$$

(3) Weight and cost of light green cotton

$$= \frac{21 \times 7 \times 55 \times 80 \times 1}{24 \times 840 \times 7} = 4\tfrac{7}{12} \times 2/4 \quad = 10 \quad 8$$

(4) Weight and cost of weft of 2/48s cotton,

$$\frac{48 \times 55 \times 68 \times 2}{24 \times 840 \times 3} = 5\tfrac{59}{63}$$

Add 5% for waste

$$= 5\tfrac{59}{63} \times 5\% = \tfrac{3}{10}$$

$\Big\}$ lbs. $6\frac{1}{4}$ at 2/4 $= 14 \quad 7$

(5) Of 2s cotton,

$$\frac{48 \times 55 \times 68}{2 \times 840} \times \tfrac{1}{3} = 35\tfrac{13}{21}$$

Add 5% for waste

$$= 35\tfrac{13}{21} \times 5\% = 1\tfrac{4}{5}$$

$\Big\}$ lbs. $37\frac{3}{7}$ at 1/8 $= 62 \quad 4\frac{1}{2}$

(6) Cost of weaving = 68 yards at 1/2	= 79	4
(7) Cost of finishing = 64 yards at 3d.	= 16	0
(8) General expenses, 64 yards at 3/-	=192	0
Actual cost	=588	$8\frac{1}{2}$
Cost of commission, etc., $7\frac{1}{2}\%$	= 44	$1\frac{1}{2}$
Total cost	632	10

Weight out of loom = $83\frac{6}{7}$lbs.

Loss in scouring 10% = $8\frac{1}{3}$lbs.

Actual weight of piece finished = $75\frac{11}{21}$lbs.

And weight per yard = $\frac{75\frac{1}{2} \times 16}{64}$ = $18\frac{7}{8}$ ozs.

And 64 yards less 1 yard over-measure = 63 yards.

$\therefore \frac{632\text{s. } 10\text{d.}}{63 \text{ yds.}}$ = 10s. $0\frac{1}{2}$d. per yard.

Costing Cotton Cloths.

In the cotton manufacturing district of Lancashire a uniform list of prices to be paid for weaving is fixed, together with additions and deductions for every conceivable change in width of reed, length of warp, ends and picks per inch, twist of warp and counts of weft, weave or pattern whether plain or coloured of every possible variety. To the above must be added the incidental factory expenses which are from $\frac{1}{2}$ to the whole of the cost of weaving. In addition there are local systems which for general purposes can be ignored. The standard price is made for a plain loom 45″ reed space producing cloth 39 to 41 inches wide; ends per inch 60 and picks per quarter inch 15 plus $1\frac{1}{2}\%$ for contraction; length of piece 100 yards (36″)

twist of warp 28s or finer, counts of weft from 31s to 100s; amount paid to weaver is reckoned at pence per $\frac{1}{4}$ pick or a fixed amount for the web.

A varying amount per cent. is added or deducted for each inch, more or less of the warp in the reed, *e.g.*, $1\frac{1}{2}\%$ is added per inch up to and including 51 inches, 2% from 51 to 56, $2\frac{1}{2}$ from 56 to 64 and 3% from 64 to 72 inches. The deductions are $1\frac{1}{4}\%$ from 45 to and including 37 inches; 1% from 37 to 24 inches and below. The complete list is very lengthy and may be obtained from either the cotton employers' or operatives' association.

Example 7.—Ascertain the cost per yard of a grey cotton cloth which measures 100 yds. (36″) over the counter. Warp 30s twist, 108 yards at 20d. per lb., set 60 ends per inch, 40″ wide in the reed and woven with 15 picks per $\frac{1}{4}$ inch of 32s cotton in cops at 18d. per lb. Price to be paid for weaving 4d. per $\frac{1}{4}$ pich, add $\frac{3}{4}$ cost of weaving to cover general expenses. Add $2\frac{1}{2}\%$ to cost of warp and 4% to cost of weft for waste.

(1) Cost of warp

$$= \frac{\text{Ends per inch} \times \text{width in reed} \times \text{length of warp} \times \text{cost per lb.}}{\text{No. of yards of warp twist per lb.}}$$

$$= \frac{60 \times 39 \times 108 \times 20}{30 \times 840} = 200{\cdot}6 \text{ pence}$$

plus waste per cent. $= 200{\cdot}6 \times 2\frac{1}{2}\% = 5{\cdot}$,,

(2) Cost of weft

$$= \frac{\text{Picks per inch} \times \text{width in reed} \times \text{length of cloth} \times \text{cost per lb.}}{\text{No. of yds. per lb. of weft}}$$

$$= \frac{60 \times 40 \times 100 \times 18}{32 \times 840} = 160{\cdot}6 \text{ pence}$$

plus waste per cent. $= 160{\cdot}6 \times 4\% = 6{\cdot}4$,,

(3) Cost of weaving 15 picks per $\frac{1}{4}''$ at 4d. = 60· ,,
(4) General Expenses $\frac{3}{4}$ of weaving = $60 \times \frac{3}{4}$ = 45· ,,

Total cost of cloth in pence = 477·6 ,,

$\therefore$ Cost per yard = $\frac{477 \cdot 6}{100}$ = 4·776 pence.

Example 8.—Find the cost of a cotton cloth woven with 56 threads of 40s twist warp (a) 2/2 per lb., 32·3″ wide, 48 picks per inch of 32s cotton weft at 20d. per lb. Weaving 4d. per $\frac{1}{4}$ pick per 100 yds. of warp. Expenses half weaver's wage, finishing 3/4, finished length of piece 90 yds. Add 5% for waste of weft; shrinkage 5% in width and 6% from taper's length to loom state.

Reed width $\frac{32 \cdot 3 \times 100}{95} = 34''$

pence.

(1) Cost of warp = $\frac{56 \times 34 \times 100 \times 26}{40 \times 840}$ = 147

Length of piece = 100 − 6 = 94 yds.

(2) Cost of weft = $\frac{48 \times 34 \times 94 \times 105 \times 20}{32 \times 840 \times 100}$ = 120
(3) ,, weaving = 12 picks per $\frac{1}{4}$ in. at 4d = 48
(4) Expenses half weaving = 24
(5) Finishing ... ... = 40

Total cost of piece = 379

$\therefore$ Cost per yd. = $\frac{379}{90}$ = 4·2 pence.

Example 9.—Find the total cost and cost per yard of the following fancy striped cotton fabric:—Warp 330 yards producing 300 yards of cloth, woven 33 inches wide in the reed and containing 66 ends and

64 picks per inch respectively ; the pattern is warped
40 threads slate, 4 threads white mercerised.
16 ,, ,, 12 ,, ,, ,,
16 ,, ,, 4 ,, ,, ,,
40 ,, ,, 4 ,, ,, ,,

Add 32 threads of 2/40s bleached cotton for selvedge at 2/4 per lb. ; cost of 2/40s mercerised cotton 5/- ; slate coloured warp 36s twist at 2/4 ; slate weft 32s in hank at 1/8 ; dyeing warp at 7d. and weft at 5d. ; bleaching selvedge at 1½d., sizing coloured warp at ¾d. per lb. ; winding 36s twist warp at 2d. per 32 hanks, 2/40s mercerised warp and 32s weft at 2d. per 20 hanks ; warping 1/4 per 1000 hanks ; beaming 4d. per 100 yards and looming 1/- per 1000 ends ; weaving 6d. per ¼ pick per 100 yds. of cloth ; general expenses for machinery, datal wages etc. in preparation and weaving the same as cost of weaving. Add 5% for waste of warp and weft.

In the solution of the foregoing it is better to find the warp and weft independently of the allowance for waste and cost so as to facilitate the tabulation of cost of dyeing, bleaching, mercerising, winding, etc.

1. Weight and cost of warps :—

NOTE.—The number of threads of each sort in one repeat of the pattern equals 112 of slate and 24 of mercerised white, total 136 exclusive of edges.

(a) Slate warp.

$$= \frac{66 \times 33 \times 330}{36 \times 840} \times \frac{112}{136} = 19{\cdot}57 \text{ lbs.}$$

plus waste $= 19{\cdot}57 \times 5\% = 1$

	s.	d.
20·57 at 2/4	= 48	0

(b) Mercerised warp.

$$= \frac{66 \times 33 \times 330}{20 \times 840} \times \frac{24}{136} = 7{\cdot}55$$

plus waste $= 7{\cdot}55 \times 5\% = 0{\cdot}37$ } 7·92 at 5/- = 39 7

(c) Selvedge.

$$= \frac{32 \times 330}{20 \times 840} = 0{\cdot}63 \text{ at } 2/4 = 1\ 6$$

2. Weight and cost of weft.

$$= \frac{64 \times 33 \times 300}{32 \times 840} = 23{\cdot}57$$

plus waste $= 23{\cdot}57 \times 5\% = 1{\cdot}17$ } 24·74 at 1/8 = 41 3

3. Dyeing slate warp 19·57lbs. at 7d. = 11 5

4. Dyeing weft 23·57lbs. at 5d. = 9 10

5. Bleaching selvedge ·63lbs. at 1½d. = 0 1

6. Sizing slate warp 19·57lbs. at ¾d. = 1 2

7. Winding 36s twist warp at 1d. per 32 hanks

$$= \frac{19{\cdot}57 \text{ lbs.} \times 36 \text{ hanks}}{32 \text{ hanks}} \text{ at 2d.} = 3\ 8$$

8. Winding 2/40s white warp at 2d. per 20 hanks

$$= \frac{7{\cdot}55 \text{ lbs.} \times 20 \text{ hanks per lb.}}{20 \text{ hanks}} \text{ at 2d.} = 1\ 3$$

9. Ditto weft.

$$= \frac{23{\cdot}57 \times 20}{32} \text{ at 2d.} = 2\ 6$$

10. Warping at 16d. per 1000 hanks.

Slate warp $\frac{19{\cdot}57 \text{ lbs.} \times 36 \times 16}{1000} = 11$

11. White warp $= \frac{7{\cdot}55 \text{ lbs.} \times 20 \times 16}{1000} = 2\frac{1}{2}$

12. Beaming per 330 yards at 4d. per 100 = 1 1½

13. Looming (66×33) at 1/- per 1000	=	2	2
14. Weaving 3 cuts of 100 yds. each at 6d. per ¼pk. =3×6×16	=	24	0
15. Miscellaneous expenses	=	24	0
Total cost	=	£10	12	8

$$\therefore \text{ Cost per yard } = \frac{£10\ 12\ 8}{300} = 8\tfrac{1}{2}\text{d.}$$

Costing Linen Fabrics.

The cost of weaving linen fabrics, like all other woven textures varies according to the many factors which enter into their construction, *e.g.*, width and length of web ; set of warp and shots of weft ; the kind of loom in which the fabric is woven, whether tappet, dobby, jacquard, single shot or check ; the condition of the yarn whether grey, boiled, partly or fully bleached ; the severer the treatment, the higher the payment ; if the fabric be a union, *i.e.*, a cotton warp and linen weft, then it will require less trouble in weaving, and the payment will be accordingly. The system of payment for weaving, differs somewhat from worsted, woollen or cotton goods, where the price is frequently fixed at so much per quarter, half or whole pick for some fixed length of warp, width and type of loom, and where any alteration in the number of picks or length of warp involves a change in price pro rata.

In linen weaving most manufacturers pay a fixed price per web for a given standard fabric, which has been determined by carefully noting the time that it has taken to weave each specific fabric.

As an alternative method the amount which should

be paid for weaving each given make of fabric may be pre-determined by *calculation* on the basis of the average running in picks per minute for any and all classes of looms which the factory contains. Such average running may be obtained by taking the total production of webs (for each week) multiplied by their respective shots of weft and dividing the product by the total number of looms in the factory ; each week's running is then added together and the average is struck for 6 or 12 months.

The average running time thus obtained allows not only for stoppages of the particular loom on which a given fabric is being woven but it gives the average for all the looms in the factory which may be out of order or without warps ; such a plan ensures the costing being slightly on the right side ; of course in the event of a large order being in the balance, the actual *average* running of the looms intended to weave the prospective order might be greater than the average for the whole factory in which case the cost would be proportionately less and which might therefore be the deciding factor in accepting or otherwise of the order.

The manufacturer also makes periodical tests to determine the proportionate cost per day of all datal employees, plant, power etc. for each type of loom of given width and capacity. From these he can readily approximate the incidental or factory expenses on any given make of fabric when he knows the time required to weave it.

e.g. If the cost per day of all datal and factory expenses works out at 4/- and if the web has taken 1½

days to weave after allowing for stoppages of all kinds, the incidental expenses on such a fabric would be $1\frac{1}{2}$ times 4/-= 6/-. The amount to be paid for the actual weaving would also be determined according to the time taken to produce the given fabric. The price thus arrived at becomes the fixed sum for all subsequent webs of corresponding make and length of warp.

Example 10.—Assume that the average running of 1000 looms of all widths as follows is 75 picks per minute, due allowance having been made for all stoppages; there are 300 looms with 43″ reed space, 200 with 52″, 150 with 56″, 150 with 72″, 100 with 76″, and 100 with 84″. If datal expenses including cost of machinery, plant, interest, depreciation etc. amount to the sum total of £1008 6s. 8d per week, find the average cost per loom per day for the average reed space, also the cost per day for each loom of given reed width pro rata—all single shuttle looms.

1. Then average number of ins. reed space per loom=

43″	× 300 looms	=	12900″
52	× 200 ,,	=	10400
56	× 150 ,,	=	8400
72	× 150 ,,	=	10800
76	× 100 ,,	=	7600
84	× 100 ,,	=	8400
	1000 looms	=	58500″ or 58·5″ per loom.

2. Average cost per loom per week $= \frac{£1008\ 6\ 8}{1000} = 20/2$

,, ,, ,, ,, day $= \frac{20/2}{5\frac{1}{2}} = 3/8$

3. Then

As 58·5 : 43 : : 3/8 : 32·34 or approx. 2/8
and ,, 58·5 : 52 : : 3/8 : 39· ,, 3/3
and ,, 58·5 : 56 : : 3/8 : 42·1 ,, 3/6
and ,, 58·5 : 72 : : 3/8 : 54·16 ,, 4/6
and ,, 58·5 : 76 : : 3/8 : 57·16 ,, 4/9
and ,, 58·5 : 84 : : 3/8 : 63·16 ,, 5/3

Example 11.—Given the cost per day of 9 hours at 4/6 for 72″ reed space, find the total incidental expenses for weaving a damask web laid 54 yards of warp, and containing 12 shots of weft, and producing 50 yards of 37″ cloth. Effective running 75 picks per minute.

Then shots in web = Shots in glass × 200 × length of web.

and $\frac{\text{Total number of shots in web}}{\text{Total number of picks per day}} = \text{Time in days required to weave the web.}$

$$= \frac{12 \times 200 \times 50}{75 \times 60 \times 9} = 2{\cdot}96 \text{ days.}$$

Incidental expenses 4/6 × 2·96 = 13/4

The *loom rent* for weaving the above fabric includes all the incidental charges on Capital, viz :—interest, depreciation, renewals, insurance, fuel, light and proportional administration and datal costs. These reckoned at approximately twice the pre war rates would be about 12/-.and the winding, warping, dressing and tieing-in about 6/- and the cost of Jacquard cards at about 2/- per web based on not less than 100 webs.

It may appear singular, but a careful analysis reveals that the *total* factory expenses, including weavers' wages, on each web, in the majority of cases, is 3 times the amount paid to the weaver.

Allowance must also be made for waste in preparing

and weaving, which is usually about $2\frac{1}{2}\%$ for warps and 5% for weft added to the actual cloth weight.

Example 12.—Given 90 yards of grey cloth of 37″ measure made from 100 yds. of 60s line warp at 12/6 per bundle less 11% woven in 13°° reed, 40″ scale and 40″ reed width with 15 shots under 37″ glass, 60s lea weft costing 11/- per bundle less 11%. Add $2\frac{1}{2}\%$ for waste in warp and weft and allow 27/- for weaving and factory expenses. Find the total cost and weight of web.

(1) Cost per bundle of warp = 12/6 less 11% = $(75 - 8\frac{1}{4}) = 133\frac{1}{2}$d.

(2) ,, ,, weft = 11/- ,, 11% = $(66 - 7{\cdot}26) = 117\frac{1}{2}$

(3) Cost of warp = $\frac{1300 \times 2 \times 100}{60000} \times \frac{205}{200} \times \frac{133\frac{1}{2}}{12}$ = £2 9 6

(4) ,, weft = $\frac{15 \times 200 \times 90}{60000} \times \frac{40}{36} \times \frac{205}{200} \times \frac{117\frac{1}{2}}{12}$ = £2 10 0

(5) Total weaving and factory expenses = £1 7 0

Total cost of web = £6 6 6

(6) Weight of web = weight of warp + weight of weft.

(a) Warp = $\frac{1300 \times 2 \times 100}{60 \times 300}$ = $14{\cdot}\dot{4}\dot{4}$ lbs.

(b) Weft = $\frac{15 \times 200 \times 90 \times 40}{60 \times 300 \times 36}$ = $16{\cdot}\dot{6}\dot{6}$ lbs.

Total weight of web = 31·11 lbs.

Example 13.—Find the cost per 37″ yard of brown linen woven in a 10°° reed, 40″ scale, 40″ reed width, 78 yards of warp, producing 72 yards (37″) of cloth, 40s lea warp and weft, costing 11/- and 10/6 per bundle net respectively, 10 shots of weft, 37″ glass. Add for total factory expenses $2\frac{1}{4}$d. per yard and $2\frac{1}{2}\%$ for waste of warp and weft.

Cost of warp = $\frac{1000 \times 2 \times 78 \times 205 \times 11}{60000 \times 200}$ = 29·4

$$,, \quad \text{weft} = \frac{10 \times 200 \times 72 \times 40 \times 205 \times 21}{60000 \times 36 \times 200 \times 2} = 28{\cdot}8$$

Total cost of web = 58·0

$$\text{Then } \frac{58/-}{72 \text{ yds.}} = 9\tfrac{2}{3} \text{ pence.}$$

$$\text{And } 9\tfrac{2}{3} + 2\tfrac{1}{4} = \frac{116 + 27}{12} = 11\tfrac{1}{12} \text{ or } 11{\cdot}9\text{d. per yd.}$$

Example 14.—Find the cost per dozen huckaback towels 24 inches wide by 39 inches in length plus 3 inches of fringe at each end. Width of warp in reed 26″, 56 ends per inch of 15s cotton at 2/4 per lb., bleaching 2d. per lb. ; 24 double picks per inch of 16s lea dry spun flax weft at 2/8 per lb., bleaching $2\frac{1}{4}$d. per lb., one inch border of 6s Turkey red cotton (double weft) at 2/8 per lb. ; length of warp 120 yds. producing $112\frac{1}{2}$ yds. of towelling including fringe. Total cost of weaving 14/- per web. Add 5% for waste of weft in weaving.

(1) Cost of warp and bleaching

$$= \frac{\text{Ends per inch} \times \text{reed width} \times \text{length of warp}}{\text{Yards per lb.}} = \text{wt. in lbs.}$$

$$= \frac{56 \times 26 \times 120}{18 \times 840} = 13\tfrac{13}{15} \text{ lbs. at } 2/4 = 32{\cdot}4$$

and bleaching $13\frac{13}{15}$ lbs. at 2d. = 2·4

(2) Cost of flax weft and bleaching

$$\frac{\text{Picks per in.} \times \text{reed width} \times \text{length of web} \times \left(\frac{100 + \text{waste\%}}{100}\right) \times \text{ins. of given weft in towel}}{\text{Yards per lb. of given weft} \times 100 \times (\text{No. of ins. of towel} + \text{fringe.})} = \text{wt. in lbs.}$$

$$= \frac{(24 \times 2) \times 26}{16 \times 300} \times \frac{225}{2} \times \frac{105}{100} \times \frac{37}{45} = 25\tfrac{1}{4} \text{ lbs. at } 2/8 = 6\ 7\ 4$$

Bleaching $= 25\frac{1}{4}$,, at $2\frac{1}{4}$ = 4 9

(3) Cost of Turkey red weft

$= \frac{(24 \times 2) \times 26 \times 225 \times 105 \times 2}{6 \times 840 \times 2 \times 100 \times 45} = 1\frac{11}{10}$,, at 2/8 = 3 6

Total cost for weaving = 14 0

Total cost of web $112\frac{1}{2}$ yds. long = 124 3

(4) No. of towels of 45″ length in web

$= \frac{225}{2} \times \frac{36}{45} = 90$ towels

$\therefore$ Cost of 1 doz. towels $= \frac{\text{Total cost of web}}{\text{Total No. of towels}} \times 1 \text{ doz.} = \frac{124 \times 12}{90} = 16/6.$

BUYING AND SELLING PRICES OF WOVEN CLOTHS.

In every system of costing all the factors which influence the net return of goods sold must be considered so that the actual profits may be correctly estimated. These factors vary widely in the merchanting of woven fabrics as in every other business and include—

1. The extent of the establishment and volume of trade, financial standing and credit and banking facilities.

2. Proximity to the markets, railways and docks.

3. The class of goods offered for sale and their relative value as compared with weight and bulk.

4. Packing, simple or complex, to suit mode of transit and destination.

5. Insurances, interest and depreciation charges for capital invested permanently and temporarily.

6. Dyeing and finishing charges, if any.

7. Whether the manufacturer sells directly through his own staff of travellers or through accredited agents.

N.B.—All the aforementioned miscellaneous costs must be ascertained over a period of 6 or 12 months'

business, and reduced to one common denominator of fixed charges per square yd., according to weight, quality and value or per linear yard for the different widths of cloth.

Example 15.—Calculate the net price per yard of bleached 4/4 plain linen. The factory price for the loom and brown state is 20½d. per yard less 3½% ; the "outcome" increases 6% and the charge for bleaching is 2d. per yard less 5%.

Data: (1) Plain linen increases in length from 5% to 10% from the loom or brown state to the bleached and finished length—a contraction in width results, as a consequence.

(2) The charge for bleaching is always reckoned on the grey length.

Solutions— Pence.

Initial cost per yard $= 20{\cdot}5$

Less 3½% discount $\frac{20{\cdot}5 \times 3{\cdot}5}{100} = 0{\cdot}7175$

Net initial cost yd. $= 19{\cdot}7825$

Net cost per yd. for bleaching & finishing $\frac{2 \times 95}{100} = 1{\cdot}9$

Cost per yd. of bleached and finished cloth (grey length) ... ... $= 21{\cdot}6825$

Net cost per yd. bleached and finished length $= \frac{21{\cdot}6825}{1} \times \frac{100}{106} = 20{\cdot}45$

The above may be expressed in one simple formula as follows :—

$$= \left(\begin{matrix} \text{Initial cost yd.} \\ \text{less disct.} \end{matrix} + \begin{matrix} \text{Net cost yd.} \\ \text{blchg. \& finishing} \end{matrix} \right) \div \text{Outcome}$$

$$= \left(\frac{20{\cdot}5 \times 96{\cdot}5}{100} + \frac{2 \times 95}{100} \right) \times \frac{100}{106} = 20{\cdot}45$$

EXERCISES.

Woollens, Worsteds, and Unions.

1. A cloth is made with 126 ends per inch of 2/48s worsted at 5/4 per lb. ; weft, 2 picks of 2/48s worsted to 1 pick of 20 skeins woollen at 3/- per lb. ; 96 picks per inch ; reed width 35 inches, 75 yards of warp ; 64½ yards of cloth. Allow 5% for waste of weft in weaving. Find the total cost of the material.

Ans., £11 15s. 9d.

2. Find the total cost of the material in a cloth made as follows :—Warp 72 ends per inch of 2/60s cotton ; weft 80 picks per inch 36s worsted ; reed width 64 inches ; length of warp 54 yards ; length of piece 48 yards ; cost of cotton 4/8 per lb., and of worsted 6/8 per lb. Add 5% to weight of weft to cover waste in weaving.

Ans., £6 11s. 5d.

3. Find the cost of material in a piece of worsted coating cloth made as follows :—Warp 2/36 at 6/- per lb. : weft 18s at 5/8 ; 76 ends and 80 picks per inch ; 66 inches wide in the sley ; 52 yards long made from 60 yards of warp, allowing 7½ per cent. for actual waste of weft in weaving.

Ans., £17 5s. 1d.

4. Find the cost of weft in a cloth 50 yards long woven in a reed 34 inches wide with 18 picks per 1 inch ; 1/20s cotton at 1/6 per lb. Add 5 per cent. for waste of weft.

Ans., 11s. 6d.

5. Find the cost of material for a cloth made from 2/48s worsted warp 64 ends per inch ; 18s worsted weft, 64 picks per inch ; warp 6/4 per lb. ; weft 5/10 per lb. ; length of warp 70 yards ; length of piece 63 yards. Allow 5 per cent. for waste of weft in weaving ; width in reed 66 inches.

Ans., £15 1s. 0d.

6. Calculate the cost per yard of a dress fabric made as follows :—Warp 72 ends per inch 2/80s super cotton at 5/4 per lb. ; 84 picks per inch of 36s worsted at 6/- per lb. ; warp 29½ inches in the reed ; 48 yards long from 54 yards warp.

Add 5 per cent. to weight of weft for waste in weaving; cost of weaving 5d. per $\frac{1}{4}$ pick; incidental expenses $1\frac{3}{4}$ times the weaving; add 5 per cent. for commission, etc. Finished length of cloth 45 yards (37 inches) 44 yards to be charged. Cost of finishing 7/-. *Ans.*, 2s. $0\frac{3}{4}$d.

7. Required the weight and cost per yard of a worsted cloth made as follows:—Warp 2/40s at 5/6 per lb.; weft 2/48s at 5/8 per lb.; 64 ends and 72 picks per inch; 63-inch reed width; length of warp 65 yards, length of piece 60 yards, finished length 55 yards (37 inches); cost of weaving 1/2 per $\frac{1}{4}$ pick; incidental expenses twice the weaver's wage; dyeing, burling and finishing 48/-; length of warp to be taken to cover waste of weft in weaving; add 5 per cent. to total cost for commissions, etc. Allow 1 yard over measure; weight of dyed cloth equals calculation weight.

Ans., $12\frac{3}{4}$ ozs.; 7s. 1d.

9. Find the cost per yard of a fabric constructed as follows: Warp 90s set Bradford, consisting of 1 end of 2/60s worsted at 5/6 per lb. to 1 end 2/40s cotton at 3/- per lb.; reed width 54 inches; length of warp 56 yards; length of piece 52 yards, finished length 47 yards (37 inches); weft 1/32s English at 4/- per lb., 60 picks per inch; cotton 1/40s at 2/8 per lb., 40 picks per inch; cost of weaving 1/4 per $\frac{1}{4}$ pick; incidental expenses twice the weaving; length of warp to cover waste of weft; burling and finishing 20/-; add 5 per cent. for commission, etc. Allow 1 yard over-measure.

Ans., 5s. $6\frac{1}{2}$d.

10. What is the weight and cost per yard of the following cloth:—Warp 80s set Bradford; 2/32s worsted at 5/8; 66-inch reed; 75 yards warp; 67 yards grey; 61 yards finished (37 inches); weft 26 picks per $\frac{1}{4}$ inch; 20s worsted at 5/6 per lb.; cost of dressing, twisting and weaving on commission 3/- per quarter pick; length of warp to cover waste of weft in weaving; dyeing and finishing 48/-; burling and mending 10/-; add $7\frac{1}{2}$ per cent. of the total cost to cover owner's expenses; allow for 1 yard over-measure.

Ans., $23\frac{3}{4}$ ozs.; 11s. $11\frac{1}{2}$d.

11. A Scotch tweed is made with 30 ends and picks per inch; warp and weft 14-cut Gala. at 5/- per lb.; 66 inches reed width required to produce 54 inches finished (37 inches); 80 yards produce 72 yards grey and 63 finished (37″). Cost of weaving 20/-; incidental expenses £2; add 7½ per cent. to weight for waste of weft in weaving; 25/- for knotting, scouring and finishing; add 5 per cent. to total cost to cover travelling expenses and commission. Loss in scouring and finishing 15 per cent. Find the weight and cost per yard; allow 1 yard over-measure.

Ans., 23¼ ozs.; 10s. 10d.

12. A fancy worsted coating double cloth is constructed to the following particulars:—

Face Warp 72 threads per inch 2/44s Botany at 5/8 per lb.
Back ,, 36 threads per inch 2/24s Botany at 5/6 per lb.

Reed width 63 inches; length of warp 70 yards, which length is to cover the cost of waste in weaving; finished length of piece 56 yards (37 inches); weft and picks as warp: price per ¼ pick for weaving 2/-; mill and general expenses twice the cost of weaving; mending, 10/-; cloth finishing 24/-; allow 7½ per cent. on total cost for commission, travelling expenses, etc., and the usual 1 yard over-measure. Find the cost per yard. *Ans.*, 14s. 7d.

13. Find the weight and cost per yard of a mantle fabric made to the following particulars:—

Warp 2/48s worsted at 6/- per lb., 63 set Bradford.
Weft:—

For 4 picks { 1 pick 30/2 spun silk (figuring) at 28/- per lb.
1 pick 24s worsted (ground) at 4/- per lb.
1 pick 10s skeins woollen (backing) at 3/- per lb.

168 picks to the inch.

Width in reed 32 inches, 60 yards of warp give 53 out of loom, and 50 yards finished (37 inches); allow 8 per cent. for waste of weft; cost of weaving 13d. per yard grey length; general expenses £4; 900 Jacquard cards at 1d.; finishing 10/6; allow 7½ per cent. of total cost to cover commission, etc., and 1 yard over-measure. *Ans.*, 14½ ozs.; 11s. 9½d.

14. What is the weight and cost per yard of a Union Woollen dressed face cloth made as particulars given herewith ? Warp, 24 strings 2/24s cotton at 2/4 per lb. ; 72 inches reed width ; 27 ends per inch ; weft, 8 Y.S. woollen at 4/8 per lb. ; 35 picks per inch. Cost of weaving 7d. per string ; dyeing and finishing 72/- ; 78 yards of cloth grey (36 inches), 76 yards (37 inches) finished ; allow 19/- for general expenses and 5 per cent. of total cost for travelling expenses, etc. ; deduct 10% nett loss after dyeing, scouring, cropping and finishing and 1 yard over-measure ; add 5% to weight of weft to cover waste in weaving.

Ans., 21 ozs. ; 8s. 6½d.

Cotton and Silk.

15. What is the total cost of a cotton cloth constructed thus :—Warp 80 yards of 80s twist at 3/10 per lb. on the warp beam, 100 ends per inch, 48 inches wide ; weft 20 picks per ¼ inch of 100s twist at 4/- per lb. ready for weaving ; length of piece 76 yards ; weaving 10/- ; mill expenses 1½ times the weaving cost ; commissions, travelling expenses, etc., 5 per cent. Allow 5 per cent. for waste of weft in weaving.

Ans., £3 4s. 7d.

16. Find the cost per yard of a cotton cloth, grey, made as follows :—80 yards of warp of 30s twist at 1/4 per lb. in cop ; 64 ends per inch ; 42 inch reed ; length of cloth 75 yards ; weft, 15 picks per ¼ inch ; 24s. on cop at 1/- per lb., winding warp and weft 1d. per lb. ; weaving 4d. per ¼ pick ; 1¼ times weaving to cover warping, sizing, twisting, and other mill expenses ; add 5 per cent. to weight of weft for waste in weaving ; and 5 per cent. commission on total cost.

Ans., 6d.

17. A figured silk texture is made with 108 yards of warp of 3 dram silk ; 200 ends per inch at 52/6 per lb. when ready for weaving ; weft in 3 shades 252 picks per inch of 4 dram silk costing 48/- per lb. when ready for weaving. Length of piece 100 yards ; cost of weaving cloth 8d. per yard. Design cut and laced on 1000 cards at 1d. each ; cloth repairing and

finishing, etc., 40/-. General expenses 10 per cent. on total cost; reed width 25 inches, including 1 inch for edges of 120 ends 30/2 spun silk at 15/- per lb. 99 yards to be charged for. Find the cost per yard.

Ans., 11s. 0d.

18. What is the cost of 1 dozen tapestry table covers, particulars as follows :—

32 by 34 inches, width in reed 33 inches. Warps—

{ 600 ends 2/60s cotton, Indigo blue at 6/- per lb.
{ 4864 ends in two shades at 2/8 per lb. of 2/40s cotton.

Weft 60 picks per inch in two shades of 6s. cotton at 2/2 per lb. Cost of weaving per dozen 2/6; incidental expenses 20 per cent. more than weaving; add 5 per cent. for waste in both warp and weft; allow 5 per cent. for take-up of 2/40s, and 10 per cent. for take-up of 2/60s cotton.

Ans., £1 7s. 2d.

19. A decorative reversible double cloth is composed of the following materials :—

Warp { 1 thread 2/36 cotton, cream
{ 1 thread 2/36 cotton, deep brown } at 3/- per lb.

Set 180 threads per inch 55 inch reed.

80 yards of warp produce 70 yards out of loom and 66 yards (37 inches) finished.

Weft { 1 pick 1375 yards per oz. tram silk at 66/- per lb.
{ 1 pick 2/36s cotton at 3/- per lb.

74 picks per inch

Cost of weaving 9d. per yard on grey length; cost of finishing 1⅜d. per yard on finished length; general expenses and commission 1/3 per yard; 800 Jacquard cards at ½d. each; add 5 per cent. to cost of weft for waste; weight of finished cloth 4 per cent. less than calculation weight. What is the weight and cost per yard of finished cloth, 65 yards only to be charged for?

Ans., 16 ozs.; 15s. 2d.

20. Work out the total cost and the cost per yard of the following striped cotton fabric :—warp 330 yards, producing 300 yards of cloth woven 33″ in reed and containing 66 ends and 64 picks per inch. The pattern is warped—

40 ends of 36s twist slate at 2/4 per lb.; 4 of 2/40s mercerised at 5/- per lb.
16 ,, ,, ,, ,, 12 ,, ,, ,, ,,
16 ,, ,, ,, ,, 4 ,, ,, ,, ,,
40 ,, ,, ,, ,, 4 ,, ,, ,, ,,

112 + 24 = 136 ends in repeat.

Allow 32 ends of 2/40s bleached cotton for selvedge at 2/5¼, including 1¼d. per lb. for bleaching. Weft 32 slate in hank at 20d. per lb. Cost of dyeing warp and weft 7d. and 5d. per lb. respectively. Sizing warp ¾d. per lb. Winding 36s twist at 2d. per 32 hanks, 2/40s mercerised warp and slate weft at 2d. per lb. Warping 16d. per 1000 hanks, beaming 4d. per 100 yds., looming 10d. per 1000 ends, weaving 6d. per ¼ pick per 100 yds of cloth. Add 5% for waste of warp and weft. General expenses and datal expenses in preparation and weaving to be reckoned at the same cost as paid for weaving.

Ans., £10 14s. 7d.; 8·58d.

Linen, Jute and Unions.

21. A linen cloth is woven in 17°° reed 40″ wide on 40″ scale and 19 shots on 37″ glass with 80s lea warp boiled, costing 11/- and 85s weft boiled at 9/6 per bundle respectively, warp laid 100 yds. web 90 yds. of 37″ measure, total factory expenses 27/- and charges for boiling 8/-. Find the total cost per web and per yard, loom state, after adding 2½% to warp and 5% to weft for waste.

Ans., £8 2s. 0d.; 20⅗d.

22. A "mixture" dress linen is woven in 10°° reed, 40″ scale, 34″ reed width and 6 shots on 37″ glass; the warp is 30s lea dyed and the weft is 2/25s lea (composed of one thread white and one thread pink). The warp costs 13/6 per bundle net including dyeing and the twist thread 30/- per bundle net; the warp is laid 100 yds. and the length of the web is 90 yds. of 37″ measure. If the total factory expenses amount to 12/- find the cost of the fabric in the loom state and the cost per yard. Add 2½% to warp and 5% to weft for waste.

Ans., £5 4s. 6d.; 1/2.

23. How many bundles of linen yarn would be required to make 20,000 yards of cloth, 37 inch measure, 34 inches in width, counting 42 ends and 54 picks per inch, made from 35s and 45s tow, adding $2\frac{1}{2}\%$ to yarns for waste; allow for contraction in width $\frac{1}{15}$; length of warp to be taken at 22,000 yards? What amount of wages would be paid for making same at 1/8 per 100 hanks for warp winding; 6d. per 1000 yards of 357 ends per bank for warping; 6d. per cut of 100 yards laid for beaming; drawing and sleying 22 warps at 10d. per 1000 ends; weft winding 3/8 per 100 hanks; weaving 3/10 per web of 100 yards laid?

Ans., Warp 536·7; Weft 682·6; £78 18s. 0d.

24. Assume a damask fabric is woven in 16°° reed, 40″ scale, 15 shots on 37″ glass, 80″ reed width, warp laid 55 yards, yielding 48 yards of 37″ cloth. The warp is 45s lea boiled, the weft 50s lea boiled, and cost 15/- and 11/- per bundle respectively; the loss in weight due to boiling is 8%; add $2\frac{1}{2}\%$ to weight of warp and 5% to weight of weft to cover waste. Amount paid for weaving 13/-; other factory expenses to be reckoned at twice the wages paid for weaving; total charges for boiling 11/-. Find the cost per 37″ yard and of the complete web.

Ans., $4/2\frac{1}{2}$; £10 2s. 0d.

25. Required the cost per dozen union damask table covers, also the weight of cotton warp and the number of bundles of flax weft that would have to be ordered to weave 100 cuts of warp laid 56 yards per cut, producing 51 yards of 37″ cloth, loom state and $51\frac{1}{2}$ yards finished. Width of warp in reed 70″, 68″ cloth and 66″ finished; made from 20s cotton warp costing 2/- per lb., and bleaching same 2d. per lb.; 25s tow weft at 12/- per bundle and bleaching $2\frac{1}{4}$d. per lb.; woven 60 ends and 40 picks per inch; add 5% to weft to cover waste; charge for weaving 4/6; other factory expenses 13/6 per web; allow 68 inches to each cover.

Ans., £1 15s. 7d. per doz.; 1400 lbs.; 256·84 bundles.

26. Calculate the cost per yard of a 27″ bleached union huckaback. Woven 9°° on 37″ scale, 55 shots per inch, $\frac{3}{5}$ of

warp is 20s line at 16/6 per bundle bleached, $\frac{3}{5}$ of warp is 2/16s cotton at 18d per lb. bleached, width of warp in reed 30″. Weft 18s tow at 15/6 per bundle bleached, length of warp 80 yards producing 72 yards of cloth, add 4% to cover waste; total factory expenses 20/4.

Ans., 1/3.

27. Calculate the cost per yard of a bleached double damask 72 inches wide, woven 12°° reed 40″ scale, three threads per split, 27 shots per 37″ glass, finished. Contraction from reed width to finished width 7%, and from warp length to cloth length, 4%. Add 3% to all quantities for waste. Warp 50s line boiled at 11/- per bundle, weft 75s line boiled at 8/- per bundle. Weaving 32/- per 50 yards warp. Other expenses 55/-, bleaching and finishing 3d. per square yard.

Ans., 5/2$\frac{3}{4}$d.

N.B. *A double damask* should contain a minimum of 176 threads per square inch, and the number of threads of weft to warp should not be less than in the ratio of 3 to 2.

28. Work out the selling price for the following damasks:— (a) 8/4 bleached at 41d. per yard loom state, bleaching 2d. per sq. yard net, outcome 4% adding 7$\frac{1}{2}$% for expenses and profit and 5% for carriage and commission. (b) Bleached damask cloths in sizes $\frac{8}{4}$, $\frac{10}{4}$ and $\frac{12}{4}$ at 43d. per yard loom state, bleaching 2d. per square yard net, and adding as above. (c) 24/24 bleached napkins cost 14d. per yard (loom state), bleaching 2d. per square yard net and adding as above.

Ans., (a) 48·87d.; (b) 102, 127·16, 163d.; (c) 17·37d.

29. Work out to net price per yard finished 20 pieces 4/4 linens averaging 78 yards per piece loom price 19d. less 3$\frac{1}{2}$% outcome 7$\frac{1}{2}$%, bleaching 1$\frac{1}{2}$d. per yard net.

Ans., 18·36d.

30. Work out the selling price per yard of 72 inches damask, loom price 5/- per yard, bleaching and finishing 2d. per square yard, outcome 5%, allow 10% for profit, expenses, commission, carriage, etc.

Ans. 66·88d.

31. Calculate the selling price per yard of a union damask $55\frac{1}{2}$ inches wide. Warp 30s double cotton at 2/4 per lb., weft 20s tow bleached at 19/- per bundle, set 42/38 per inch finished. Contraction 5% in width and length. Weaving expenses $2\frac{1}{4}$d. per yard. Finishing $1\frac{1}{2}$d. per lineal yard. Allow 5% for warehouse expenses and 10% for profit.

Ans., 21·46d.

32. A finished cloth is required to measure 55 yards in length, and to weigh $10\frac{1}{2}$ ozs. per 36" yard. It costs 24 pence per yard, loom state, less $3\frac{1}{2}$% discount. The bleaching costs 2d. per yard less 5% discount. Ascertain (a) the length and weight of the web out of the loom, on an estimated outcome of 6% and loss of weight of $12\frac{1}{2}$% ; and (b) the cost per yard of the finished cloth.

Ans. (a) 51·89 yds., $41\frac{1}{4}$ lbs. ; (b) 23·64d.

CHAPTER XII.

The Construction of Woven Fabrics. A. The Diameter of Threads, and Setting of Cloths.

The chief factors to consider in the production of a properly constructed fabric are :—Weave, or method of interlacing, diameter or thickness of yarns employed, together with the relative bending powers of the warp and weft threads, and in a minor degree the quality, elasticity, strength, and the amount of twist in the materials used. The *strength* of a yarn is represented by the amount of force which it is capable of resisting up to the breaking point. The *elasticity* of a yarn is represented by its *regain* after being subjected to tension, though as a result of a series of experiments it is found that a yarn will stretch more when tension is applied from each end, than it will when the force is applied at one end only. *Twist* is put into yarn primarily to increase its strength. The *quality* of any wool is represented by the counts to which it will spin, which is governed by the length, fineness, strength, elasticity, waviness and mechanical structure of the fibre. All these in a greater or less degree exercise a modifying influence upon the diameter or thickness of the yarn. Before producing a new cloth, it is necessary to consider to what purpose it is to be subsequently applied. In some cases the fabric must be firm and smart in appearance ; in others, soft and full in the handle, which means a corresponding looseness in the

setting ; in others, open in texture as in the case of gauzes, some tapestries and decorative fabrics. Since woven fabrics consist of a series of threads arranged in one direction, and a second series which run crosswise and interlace with the first, it is very necessary to know the diameter of the threads in conjunction with the weave and the relative bending powers of warp and weft, in order to correctly determine the number of threads which can naturally be arranged side by side of either warp or weft in a given unit of space—the most rational unit being one inch. Several methods have been adopted for the purpose of determining the diameter of yarns. I have little hesitation in stating that it is scarcely possible to formulate a principle which will apply to all yarns and which is absolutely correct, and yet it is possible to establish a system which will be sufficiently accurate for all practical purposes. The *first method*, which is old and somewhat crude, consisted in selecting a series of cloths which were considered to be satisfactorily constructed, and then, knowing the number of warp threads plus intersections of the weft threads in the full width of the piece, the average diameter of the threads was obtained.

A *second method* for determining the diameter of a thread is purely mechanical, and consists in obtaining the diameter of threads by a series of measurements, then totalling these measurements and striking an average. The results are then tabulated for future use. This method is best accomplished by the use of a microscope and micrometer, by which approximate

results may be obtained, *if care is exercised.*

A *third method* is the widely accepted empirical rule, the chief feature of which is that the square root of the yards per lb. produces a number which, after making a deduction of 10 per cent. for worsted, 8 per cent. for cotton and flax, and 15 per cent, for woollen yarns, gives a result which is accepted as approximately correct. For example: there are 560 yards in 1 lb. of 15 worsted; and the $\sqrt{560} = 23{\cdot}6$. Then $23{\cdot}6 - 10\% = 21{\cdot}3$ threads per inch. But this is, as previously stated, an empirical rule, and such rules are never satisfactory unless they can be proved by the application of some external method, either of practice or theory. For this purpose, therefore, I have conducted a number of experiments upon another method which, though the most scientific, does not, for obvious reasons to which I will presently refer, yield exactly the correct diameter of the yarn. Nevertheless, it is not only interesting and instructive, but useful, inasmuch as it enables us to test the accuracy of the former rule and to formulate a basis for determining the true diameter together with the factors which influence its density. In other words, this system consists in determining the diameter of any given yarn from the specific gravity of the material.

Specific gravity indicates the density of any substance which is represented by its relative weight as compared with an equal volume of some standard substance. The standard substance for solids and liquids is usually water, of which 1 cubic foot, at a temperature of 60° F., weighs 1000 ounces.

The specific gravity of wool, as recorded by Dr. Ure, is given at 1·3, and that of cotton and flax at 1·5. That is, wool is 1·3 times as heavy as water when equal volumes of each are taken, while that of cotton or flax is 1·5 times heavier than water. As regards the general correctness of this there is little doubt, but it must, however, be obvious that the specific gravity of wool is not always the same, though the difference is not very great. Having made a series of tests, I am enabled to come to the conclusion that the specific gravity of an English wool is approximately 1·3. But "How do you determine the specific gravity of wool?", is a question which I have frequently been asked. This will be better explained by first showing how to find the specific gravity of a solid substance. Suppose, for example, we select a small piece of brass. Suspend this brass by a very fine silken thread from the under side of one of the scale pans and it is found to weigh 1700 grains in air (better in vacuo). Now immerse the body, still in suspension, in water, and it will be found necessary to remove some of the weights in the opposite scale pan. When these have been removed the weight of the solid body in water is found to be 1457 grains, showing a loss of $1700-1457=243$ grains. This apparent loss in weight is equal and is due to the upward force which the water exerts upon the body immersed. *This upward force is necessarily and always equal to the weight of water which the immersed body displaced,* otherwise the water previous to its displacement could not have been in equilibrium, for if it had been heavier it would have

sunk to the bottom, and if lighter it would have risen to the top. Further, the amount of water displaced is equal in volume to the body which displaces it; therefore, if we compare the weight of the solid substance in air with the weight of an equal volume of water, we have a number which indicates their relative densities, that is, the specific gravity of the solid substance as compared with water. Take this example: weight of solid body in air divided by its loss of weight in water:

$$\frac{\text{1700 grs. (weight in air)}}{\text{1700} - \text{1457 grs. (weight of an equal volume of water)}} = \frac{1700}{243} = 7.$$

When finding the specific gravity of wool the principle is essentially the same, the only difference being that owing to the fact that wool is not in a solid mass, more care is necessary, and on account of the air space there is within any quantity of wool which may be taken, the wool will not at first sink in water. Consequently, a "sinker," *i.e.*, a heavy solid body, has to be employed so as to immerse the wool and keep it under the water until all the air within the wool or yarn has made its escape to the surface of the water. The experiment may be quickened by pressing the wool with a small instrument immediately it is immersed. The whole should now be allowed to stand for a time until the body in water ceases to lose weight.

The following are examples worked on the principle explained:

The first consists in taking an unknown quantity of Botany wool, containing the standard allowance of moisture, thus:

Weight of wool in air =	89 grains.
,, ,, brass sinker in air =	1700 grains.
,, ,, ,, ,, ,, water =	1457 grains.
,, ,, brass and wool in water =	1478 grains.
,, ,, wool in water = 1478 − 1457) =	21 grains.
,, ,, the volume of water displaced by the wool)	(89 − 21) = 68 grains.

Therefore specific gravity of wool

$$= \left(\frac{\text{weight of wool in air}}{\text{weight of an equal volume of water}} \right) = \frac{89}{68} = 1{\cdot}3 \text{ nearly}$$

The second example consists in taking a portion of a hank of 2/36 Botany wool with the following particulars :

Weight of yarn in air =	100 grains.
,, ,, brass sinker in air =	1700 grains.
,, ,, ,, ,, water =	1457 grains.
,, ,, brass and wool in water =	1481 grains.
,, ,, yarn in water (1481 − 1457) =	24 grains.
,, ,, volume of water displaced by yarn =	76 grains.

Therefore the specific gravity of yarn

$$= \left(\frac{\text{weight of wool in air}}{\text{weight of an equal volume of water}} \right) = \frac{100}{76} = 1{\cdot}3 \text{ about.}$$

Assuming then that the specific gravity of wool is 1·3, let it be required to find the diameter of any given counts of yarn. For example, take 1s worsted, *i.e.*, a yarn which contains 560 yards per lb. Then, since the yarn is cylindrical in form and mathematics teach us that π radius^2 = area of a circle (where $\pi = \frac{22}{7}$), and knowing the length for a given weight, we are in a position to determine the number of cubic inches, etc., in the given weight of yarn. If these be compared with the same number of cubic inches in

the same weight of yarn, as is indicated by its specific gravity, there will be sufficient data then to enable us to find the value of the radius[2] from which the diameter of the yarn may be easily extracted. The following is an example :

Weight of 1 cubic foot of water at 60° F.= 1000 ounces.
,, ,, 1 ,, ,, wool (S. G. 1·3)= 1300 ounces.

Also the number of cubic inches in 1 lb. of 1s worsted equals :

CASE I.

Length multiplied by area of cross section of thread, thus :

$560 \times 36\ \pi r^2$ (where $\pi = 22 \div 7$, and r = the radius).

CASE II.

$$\frac{\text{No. of cubic inches in 1 cubic foot} \times \text{ounces in 1 lb.}}{\text{Weight of 1 cubic foot of wool in ounces}} = \frac{1728}{1300} \times 16.$$

Then since Case I. and Case II. are each equal to the number of cubic inches in 1 lb. of 1s worsted, they are equal to each other ; and if these be equated, we may easily find the value of r^2.

$$560 \times 36\pi r^2 = \frac{1728}{1300} \times \frac{16}{1}, \text{ or } r^2 = \frac{1728 \times 16 \times 1 \times 7}{1300 \times 560 \times 36 \times 22} = \frac{1}{2979}$$

$$\therefore\ r = \sqrt{\frac{1}{2979}} = \frac{1}{54{\cdot}6} \text{ and}$$

$$\text{Diameter} = \frac{1}{54{\cdot}6} \times 2 = \frac{1}{27{\cdot}3} \text{ or } 27{\cdot}3 \text{ threads per inch.}$$

which result is 6 threads per inch finer than is obtained from the previous method or given empirical rule.

Now, if wool were a solid substance this theory would be absolutely correct, but since the wool fibre is of a cellular structure it necessarily contains air spaces within its circumference ; and since the yarn is com-

posed of fibres, there are numerous small air recesses within the circumference of the yarn, consequently, the actual diameter of the yarn is greater than is revealed by specific gravity. If it were possible to correctly determine the amount of air space there is within the circumference of the yarn threads, then the absolute diameter of the threads would be readily ascertained. Taking the full range of yarns made, the air space may be anything from 20 to 30 per cent. In most of the two-fold worsted yarns it is generally about 20% but not less. This percentage of air space within the circumference of the yarns may be useful in assisting us to a determination of the maximum amount of compression to which the yarn should be subjected, either by twist in the yarn or proximity of threads in the cloth.

I have no hesitation in saying that the diameter of threads thus obtained gives a result which may be safely applied to the construction of woven textures. The foregoing theory gives a result which agrees with the 2nd and 3rd methods referred to, in the generality of cases, but the diameter as obtained by the 3rd method is an unchangeable one, while in reality, the diameter of the yarn is a constantly varying quantity, even though yarns of the same counts be selected. In the last theory given, this varying factor is taken into account.

Short Method for Finding the Diameters of Yarns.

By first ascertaining the diameter of 1s count, linen, cotton or worsted, etc., and then using this number

as a gauge point to mentally find the diameter of any other required thread, the following short method will be found useful in practice :—

Linen $16 \times \sqrt{\text{Counts}}$ 25s = Approx. dias. of yarn. = 80
Cotton $26 \times \sqrt{\text{Counts}}$ 36s = ,, ,, = 156
Worsted $21\frac{1}{2} \times \sqrt{\text{Counts}}$ 16s = ,, ,, = 88
Y.S. Woollen $14 \times \sqrt{\text{Counts}}$ 95s = ,, ,, = 42
Gala. ,, $12\frac{1}{2} \times \sqrt{\text{Counts}}$ 16s = ,, ,, = 50

No. of Diameters per inch of Standard Linen and Equivalent Cotton and Worsted Yarns.

Lea Number.	Nearest Diameters	Actual Diameters.	Nearest Equivalent.		Diameters for Worsted No.
			Cotton No.	Worsted No.	
12	55	55·2	4·3	6·4	54·2
16	64	63·75	5·7	8·6	62·5
20	71	71·26	7·2	10·7	70
25	80	79·67	9	13·4	78
30	87	87·27	10·7	16	85·5
35	94	94·26	12·5	18·8	92·5
40	101	100·77	14·2	21·4	98·7
45	107	106·88	16	24	104·5
50	113	112·67	18	27	110·5
55	118	118·17	19·4	28·5	116
60	123	123·42	21·4	32	121
65	128	128·46	23·2	35	126
70	133	133·31	25	37·5	131
75	138	138·0	27	40	135·7
80	143	142·51	28	42	140
85	147	146·9	30	45	144
90	151	151·16	32	48	148
95	155	155·3	34	51	152
100	159	159·34	36	54	156

Relative Diameter of Threads.

Having established a theory for finding the diameter of any given thread, it is comparatively easy to find that of any other. The general idea is that the diameters of threads vary inversely as the square root of their counts, and this would be correct did the density of yarns remain constant. There are two important factors which mainly influence the relative diameters of threads. (I.) The diameters of threads vary inversely as the square root of their counts, based upon the well known principle of the variation of circles. (II.) Apart from any change in the counts of yarn, its relative diameter varies in the inverse ratio of the square root of its specific gravity. In this treatise I purpose dealing only with number (I).

Example 1.—Compare circle A of 1 inch diameter with circle B of 2-inch. Area of a circle $= \pi r^2$. $\pi = \frac{22}{7}$.

Then, $\frac{\text{Area of A}}{\text{Area of B}} = \frac{\pi r^2}{\pi r^2} = \frac{\frac{22}{7} \times (\frac{1}{2} \times \frac{1}{2})}{\frac{22}{7} \times (1 \times 1)} = \frac{\frac{1}{4}}{1} = \frac{1}{4}$

$\frac{\text{The diameter of A}}{\text{The diameter of B}} = \frac{1}{2}$, but area of $\frac{A}{B} = \frac{1}{4}$,

which, it will be seen, is in the ratio of the squares of their diameters. This means then that the diameters of circles vary as the square roots of their areas. Now, since the cross section of a thread may be represented by a circle, and since, as the counts increase, the diameters of the threads decrease, it follows that the diameter of threads must vary inversely as the square roots of the areas of their cross sections. Consequently, if counts be substituted for *area of cross*

section of thread, it will be obvious that the diameters of threads (other things remaining constant) vary inversely as the square roots of their counts.

Example 2.—If the number of diameters of 16s worsted be 85, what is the relative diameter of 25s ?

Then stated according to the principle above,

$$\text{As } \sqrt{25} : \sqrt{16} :: \tfrac{1}{85} : x$$

$$= \tfrac{1}{85} \times \frac{\sqrt{16}}{\sqrt{25}} = \tfrac{1}{106}.$$

But if the 85 diameters of 16s be taken instead of $\frac{1}{85}$ which is the diameter of each thread of 16s, it will be obvious that the number of diameters per inch vary *directly* as the square roots of their counts thus :—

$$\sqrt{16} : \sqrt{25} :: 85 : x$$

$$= \frac{85}{1} \times \frac{\sqrt{25}}{\sqrt{16}} = 106.$$

The same expressed as a formula is as follows :—

FORMULA XXVIII.

$$\frac{\text{No. of diameters per inch of given counts} \times \sqrt{\text{required counts}}}{\sqrt{\text{Given count.}}} = \text{No. of diameters per inch of required counts.}$$

ELEMENTARY PRINCIPLES OF SETTING CLOTHS.

There are two great classes of woven fabrics :—

I. Those which contain relatively an equal number of warp and weft threads.

II. Those which contain relatively an unequal number of warp and weft threads.

Each of these cases may be sub-divided thus :—

1. Where thickness of warp and weft threads is equal.

2. Where it is unequal.

The relative number of threads in each of these classes depends principally upon the angles of curvature formed by the warp and weft threads. These may be classed as follows :—

(a) Where one set of threads lie perfectly straight while the other performs all the bending.

(b) Where both sets of threads form equal angles.

(c) Where each set of threads form unequal angles of curvature.

The structure of the weave is sometimes a factor in determining to which of the great classes (I. or II.) a cloth belongs, though not infrequently the same design is used in both classes, the canvas or plain weave being the most typical example.

Example 1.—Find the number of threads per inch which a cloth should contain if the diameter of the warp and weft be $\frac{1}{60}$ of an inch and the weave plain, a cross section through the warp of which is shown at Fig. 4.

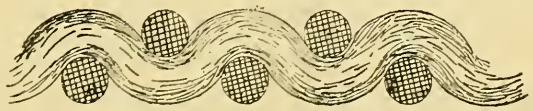

Fig. 4.

If the angles of curvature and of compression be ignored for the present it will be evident that the cloth would be made up of equal threads of warp

and *space* occupied by the weft. Thus, since the diameter of the threads equals $\frac{1}{60}$ of an inch, the space occupied by the warp and weft amounts to $\frac{1}{60} \times 2$, which equals $\frac{1}{30}$ or allows 30 threads of warp per inch. But this applies only where the number of intersections of warp and weft are equal to the number of threads in each repeat of the design; then, to find the average space available for each thread of warp when the diameters of warp and relative number of intersections of weft are known, divide the number of diameters of warp which occupy 1 inch by the number of threads plus intersections of weft in each repeat of the design, the result consequently equals the number of repeats of weave in each inch, and this, multiplied by the number of threads in each repeat of the design therefore supplies us with the number of threads of warp in each inch, exclusive of the intersections, thus :—

$$\frac{60 \times 2}{2 + 2} = 30 \text{ threads per inch.}$$

The following formula is a simplification of this reasoning :—

FORMULA XXIX.

$$\frac{\text{No. of diameters of threads per in.} \times \text{ends in 1 repeat of design.}}{\text{Ends} + \text{intersections in 1 repeat of design}} = \text{ends or picks per inch in fabric.}$$

This method gives results sufficiently accurate for all practical purposes in all cloths woven on the '*square*' or thereabouts.

Example 2.—What number of ends and picks are required to produce a cloth in a weave having 10 ends

and 4 intersections, when the counts of warp and weft are 2/40s worsted ?

No. of diameters of 20s worsted per in. $= (\sqrt{20 \times 560}) - 10\% = 95$.

Then by Formula XXIX.,

$$\frac{95 \times 10}{10 + 4} = 68 \text{ ends and picks.}$$

Example 3.—Given 2/24s worsted warp and 2/16 weft and $\frac{4}{5}$ twill, find set and picks per inch.

Diameter of 2/24s worsted $= \frac{1}{72}$ inch.

,, 2/16s ,, $= \frac{1}{60}$,,

Warp = 8 warp threads + 2 intersections of weft.

Weft = 8 weft ,, + 2 ,, ,, warp.

$\therefore$ Warp = As $(\frac{8}{72} + \frac{2}{60}) : \frac{8}{72} :: 72 : 55{\cdot}4$ ends.

And Weft = As $(\frac{8}{60} + \frac{2}{72}) : \frac{8}{60} :: 60 : 49{\cdot}6$ picks.

Example 4.—Required, the most suitable two-fold worsted yarn for a fabric which must contain 60 ends and picks per inch, woven in the $\frac{2}{2}$ twill.

Let x = the counts of the yarn required.

Equation 1. Then $\sqrt{560x} - 10\%$ = No. of diameters per inch

,, 2. Also $\frac{\text{Set} \times (\text{Ends} + \text{Intersections})}{\text{Ends in one repeat of pattern.}}$

= No. of diameters per inch

$$= \frac{60 \times (4 + 2)}{4} = 90 \text{ diameters.}$$

$\therefore$ Equation 1. is equal to Equation 2.

Then $\sqrt{560x} - 10\% = 90$.

$$= \sqrt{560x} = \frac{90 \times 100}{90} = 100$$

Square each side of the equation.

Then $560x = 100 \times 100$.

$$\therefore x = \frac{100 \times 100}{560} = 18 \text{ or } 2/36\text{s worsted.}$$

N.B.—Corkscrews, damasks and 5, 8 or 12 leaf satin twills may be set respectively about $\frac{1}{5}$, $\frac{1}{8}$ or $\frac{1}{12}$ less than the number of diameters of warp threads per inch.

EXERCISES.

1. What is the average diameter of 2/24s worsted, 2/30s cotton, 1300yds. per oz. raw silk and 20s linen ?

Ans., $\frac{1}{72}$; $\frac{1}{104}$; $\frac{1}{132}$; $\frac{1}{71}$.

2. The diameter of 20s worsted is equal to $\frac{1}{95}$ of an inch, find the relative diameter of 2/48s worsted.

Ans., $\frac{1}{104}$.

3. If 146 threads of 30s cotton laid side by side exactly cover 1 inch, what number of threads of 40s cotton would be required to cover the same unit ?

Ans., 169.

4. What is the relative diameter of 36s worsted if the thickness of 16s is $\frac{1}{85}$ part of 1 inch.

Ans., $\frac{1}{128}$.

5 Find a suitable Set Bradford for a cloth woven with $\frac{3}{2}$ twill design, the warp and weft being 2/32s worsted.

Ans., 54·6.

6. If 2/24s worsted and the Mayo twill design (8 ends, 4 intersections) be used in the production of a cloth, what number of ends and picks are required to produce a suitable cloth ? *Ans.*, 48.

7. Given 2/36s Worsted warp and weft for the face of a double cloth to be woven 2 ends and picks of cassimere face to 1 end and pick of plain back. Ascertain the set and picks for the face weave and the most convenient 2 fold yarn number for the backing warp and weft which will produce a *backing* cloth of relatively the same balance of structure as that of the face. *Ans.*, 60 ; 30 ; 2/16s.

8. Find suitable ends and picks per inch for (a) 50s linen warp and 65s weft, for 38″ plain linen ; (b) 55s linen warp and 70s weft, with diaper weave on 4 end drill base ; (c) a 5 leaf damask 35s warp and 40s weft.

Ans., 60/60 or 55/65 ; 82/85 ; 15/16.

9. What leas warp and weft of bleached and dyed yarn would be suitable for a dress material made in 900 reed, 40 inch scale, 11 shots to 37″ glass ?

Ans., 35/55 or 30/60 approximately.

10. Find suitable counts of yarn for the warp and weft of the following linen cloths. (a) Heavy interlining, counting about 37 threads per inch in warp, and 48 threads per inch in weft ; (b) Huck-towelling, counting about 47 threads per inch in warp and 54 threads per inch in weft ; (c) Light blouse linen, counting about 63 threads per inch in warp and 70 threads per inch in weft.

Ans., 20/35 ; 35/45 ; 65/80 approximately.

11. Supply yarns suitable for 12°°, 14°°, 17°°, 20°°, 24°°, and 30°° damask designs, 8 leaf twills.

Ans., 30/35, 35/40, 45/50, 60/65, 80/90, and 130/140s Practice.

CHAPTER XIII.

Construction of Woven Fabrics. B. Modifications in Fineness and Weight of Yarns and Cloth.

The chief advantage of a study of problems under this heading is the exercise and familiarisation of the mind with the fundamental principles which underlie the structure of woven fabrics.

(1) Changing the yarns or Set.

Any alteration in the counts of yarn involves a modification in the Set and picks and *vice versa*.

It has been demonstrated in Chapter XII. that the *set* and *picks* are obtained on the basis of the diameter, and they have in reality become substitutes, respectively, for the number of diameters per inch, since the set or picks represent in the aggregate a certain number of diameters of threads. Therefore the set and the picks will vary in exactly the same ratio as the diameters of threads, *i.e.*, as the square root of their counts. Consequently, any change in the counts of warp or weft will necessitate an alteration in the set and picks in the direct ratio of the square roots of their counts, and conversely, any alteration of the set and picks will require a change in the counts of yarn in the direct ratio of the squares of the set and picks, which is equivalent to saying that the counts of the yarn vary as the squares of their diameters.

Example 1.—A fabric is produced with 60 ends per inch. The yarn employed is 2/50s. It is required to

change to 2/72s. What number of ends would be necessary to retain the same relative conditions of fabric structure or proximity of threads?

2/50s = 25s, and 2/72s = 36s.

Then since 25s yarn is woven with 60 threads per inch, 36s yarn, which is finer, will require more, and since the diameters *per inch* vary directly as the square root of their counts.

$\therefore$ As $\sqrt{25} : \sqrt{36} :: 60 : x$, where x = the required set

And the means of a proportion always equal the extremes thus :—

$$\sqrt{25} \times x = \sqrt{36} \times 60$$

$$\therefore x = \frac{6 \times 60}{5} = 72 \text{ ends.}$$

FORMULA XXX.

$$\frac{\text{The sq. root of the required counts} \times \text{given set}}{\text{The sq. root of the given counts}} = \text{The required set.}$$

In the foregoing example the extraction of the square root is a simple matter, since each evolves in whole numbers of 5 and 6 respectively. In most examples the extraction of the square root of the counts would evolve an inconvenient fraction, and to avoid this, it is better to square both sides of the equation. It is an axiom, if equals be multiplied by equals, then the products are also equal to each other.

Then in the above example $x = \frac{\sqrt{36} \times 60}{\sqrt{25}}$

By squaring both sides of the equations, *i.e.*, multiplying each side of the equation by itself, we obtain,

$$x^2 = \frac{36 \times 60 \times 60}{25} = 5184$$

$$\therefore x = \sqrt{5184} = 72 \text{ ends}$$

Which is the same result as obtained above.

Example 2.—If a plain linen fabric is woven 16/18 (16^{00} reed, 18 shots 37″ glass) with 65s lea warp and 100s weft, what change in counts is necessary to retain the same balance of structure if the set and picks be reduced to 8/9.

Frequently in the linen trade, sets and picks are expressed as 7/9, 8/10, etc., which means that the set is 7^{00} and the shots 9 per glass of scale used, generally 40″ scale and 37″ glass. If ends and picks per inch are adopted as in Damasks the set and picks are written 70/80, 80/90, etc. In a similar way the counts of warp and weft are frequently written 30/40, 35/45, 50/60, etc. ; the first number indicates the warp and the second the weft.

Then as 1600 : 800 :: $\sqrt{65}$: $\sqrt{x}$.

Where x = the required counts of warp.

$$\sqrt{x} = \frac{\sqrt{65} \times 800}{1600} = 4 \therefore x = 16\text{s warp.}$$

And as 18 : 9 :: $\sqrt{100}$: $\sqrt{x}$.

Where x = the required counts of weft.

$$\sqrt{x} = \frac{\sqrt{100} \times 9}{18} = 5 \therefore x = 25\text{s lea weft.}$$

Example 3.—A cloth is woven with 40s cotton in a 60 set Bradford, what counts of cotton will be required if the set be altered to 80s Bradford ?

Then, if 60s set requires 40s yarn, 80s set being

finer, will require a finer counts of yarn, and these counts vary as the squares of their diameters or sets (explained previously), then :—

As $60^2 : 80^2 :: 40 : x$ where x = the required counts.

By multiplying *extremes* for equation 1, and *means* for equation 2, we obtain

$$60 \times 60\,x = 80 \times 80 \times 40.$$

$$\therefore x = \frac{80 \times 80 \times 40}{60 \times 60} = 71\tfrac{1}{9} \text{ counts.}$$

FORMULA XXXI.

$$\frac{\text{Given counts} \times \text{squares of required set}}{\text{Square of given set.}} = \text{The required counts.}$$

NOTE.—The above theory is not modified in any respect by the Set system or yarn denominations in which any question may be expressed so long as the factors of each equation do correspond. If in any given question these conditions are not fulfilled, then it is simply necessary to first reduce the sets to the same system and the yarns to the same denomination. This method will frequently be found the easiest and the best.

(2) CHANGING THE DESIGN.

Any change in the *weaving plan* involves a corresponding variation in the *Set* and *picks* or counts of *warp* and *weft*, assuming that the same relative balance of fabric structure is to be maintained.

I.—When counts of warp and weft remain constant.

Example 4.—If a fabric is woven with 60 ends and picks per inch, plain weave (2 ends, 2 intersections), and it is thought advisable to change to the Cassimere twill, which contains 4 ends and 2 intersections in 1 repeat of the design, what number of ends and picks would be necessary to retain the same relation of structure between the two cloths ?

The solution of this problem is simple enough, but a somewhat lengthy explanation is necessary to make it clear to the reader.

In the *plain weave* there are 2 ends and 2 intersections of weft in each repeat, making a total of 4 diameters in the cloth to every 2 threads of warp, whereas in the $\frac{2}{2}$ twill there are 4 ends and 2 intersections of weft, making a total of 6 diameters in the cloth to every 4 threads of warp. It is therefore necessary to find the relative number of diameters occupied by each design for the same number of warp threads or some other equivalent before the *required Set* can be correctly ascertained. Then find the *least common multiple* of the number of ends in 1 repeat of the designs and add their respective intersections to the L. C. M.

The given set will form a *simple proportion* with these two numbers.

The L.C.M. of these two weaves is 4.

Then in the given weave (plain) there are

2 repeats of the design = 4 ends + 4 intersections = 8 diameters

And in the required weave ($\frac{2}{2}$ twill) there is

1 repeat of the design = 4 ends + 2 intersections = 6 diameters

i.e., the plain weave with 60 ends per inch occupies 8 diameters to every 4 threads of warp, while the $\frac{2}{2}$ twill weave only occupies 6 diameters for the same threads of warp. Consequently it is possible to make a cloth with more threads of warp in the proportion,

As 6 : 8 :: 60 : x = 80 ends per inch.

From this reasoning the following simple formula may be deduced.

FORMULA XXXII.

(1) Find the L.C.M. of the two weaves.

(2) $\frac{\text{Given Set} \times (\text{Ends in L.C.M.} + \text{Intersections in given cloth})}{\text{Ends in L.C.M.} + \text{Intersections in required cloth}}$

= Required Set.

Applied to the foregoing example,

(1) The L.C.M. of the plain weave and cassimere = 4

(2) $\frac{60 \times (4 + 4)}{4 + 2} = 80$ ends and picks.

Example 5.—A cloth is woven in the $\frac{2}{2}$ twill and contains 80 ends and picks per inch. It is required to change the weaving plan to a 6-end twill with 2 intersections in each repeat of the weave. Find the Set and picks.

Then by formula XXXII.,

(1) L.C.M. of 4 and 6 = 12 ends.

In 12 ends of $\frac{2}{2}$ twill there are

12 ends + 6 intersections = 18 diameters.

In 12 ends of the 6-end twill there are

12 ends + 4 intersections = 16 diameters.

$\therefore \frac{80 \times (12 + 6)}{12 + 4} = 90$ threads and picks per inch.

II. When the Set and picks remain constant.

Example 6.—Suppose that in each of the two foregoing illustrations the Set and picks remain at 60. For the plain weave the warp and weft is 2/64s. What counts of warp and weft would be necessary to retain the same relative structure of cloth assuming that the weave is changed (1) from plain to $\frac{2}{2}$ twill, (2) from $\frac{2}{2}$ twill to a weave having 6 ends and 2 intersections in each repeat of the design?

It has just been proved that when the counts of yarn remain the same, any change in the weave involves an alteration in the Set and picks in direct

proportion to the relative number of threads and intersections of each weave. Consequently, if the Set and picks remain constant, but a change in the weave occurs, then the counts of yarn will vary in exactly the *same ratio* as they do when only an alteration of the Set and picks is made. It has been previously proved that the counts of warp or weft varies with any change of Set in direct proportion to the squares of each Set.

Therefore, when the ends and picks remain unchanged the counts of warp and weft will vary with any modification of the weave in direct proportion to the squares of their relative ends and intersections, which latter is easily obtained on the principle embodied at formula XXXII.

Then, *first*, changing from plain weave to $\frac{2}{2}$ twill.
L.C.M. of the two weaves = 4.
In 4 ends of the plain weave, there are
4 ends + 4 intersections = 8 diameters.
In 4 ends of the $\frac{2}{2}$ twill, there are
4 ends + 2 intersections = 6 diameters.

The relative number of intersections in the $\frac{2}{2}$ twill being fewer than those of the plain weave, a thicker material will therefore be necessary, *i.e.*, a lower count.

Formula XXXIII.

$$\text{As}\left(\begin{matrix}\text{Ends in L.C.M.} + \text{inter-}\\ \text{sections of given weave}\end{matrix}\right)^2 : \left(\begin{matrix}\text{Ends in L.C.M.} + \text{inter-}\\ \text{sections of req'd. weave}\end{matrix}\right)^2 :: \text{Given counts} : x$$

Where x equals the required counts.

Thus, As $(4+4)^2 : (4+2)^2 :: 32$ counts : 18s counts or 2/36s warp and weft.

Then, *second*, changing from $\frac{2}{2}$ twill to 6-end weave with 2 intersections.

L.C.M. of the two weaves = 12.
In 12 ends of the $^{2}_{2}$ twill there are
12 ends + 6 intersections = 18 diameters.
In 12 ends of the 6-end weave there are
12 ends + 4 intersections = 16 diameters.

By formula XXXIII.,

$\therefore$ As $(12+6)^2 : (12+4)^2 :: 18 : 14\frac{2}{9}$ or 2/28.

(3) Changing the Weight of a Cloth.

Where only a slight increase or decrease in the weight is necessary, using a few more or less ends and picks or slightly increasing or decreasing the counts of warp or weft (or both) are common practices. Sometimes the weave is altered, and in many instances a backing warp or weft (or both) is added to a face cloth where a large increase of weight is required and where the same surface weave and fineness of texture have to be maintained. But if a cloth has to be altered in weight, without any change of weave, and when the same relative balance of cloth structure is to be maintained, then the only correct method which will retain the same theoretical conditions is to modify the counts of the material and to alter the Set and picks so as to coincide with this changed thickness of yarn. This last assertion is proved by the fact that *theoretically there can only be one make of cloth for any given yarns and weave.*

Example 7.—A fabric is made with 84 ends per inch and woven with 49s yarn. It is required to produce another cloth of similar weave structure but $\frac{1}{6}$ heavier. Find the counts and Set.

If in this example the weight of the counts of warp

and weft were increased $\frac{1}{6}$ without any alteration in the set and picks, or, on the other hand, if the set and picks were increased $\frac{1}{6}$ without any alteration in the counts of warp and weft, then an increase of $\frac{1}{6}$ of cloth would be obtained in a very simple way, but the structure of the fabric would be deteriorated.

Obviously, then, the only course open is to increase the weight of yarns to such an extent that when the set and picks are reduced to suit the changed diameters of yarn, the weight of the fabric will exactly coincide with the required weight of cloth. It is found that, if instead of simply increasing the weight of the yarns $\frac{1}{6}$, the diameter is increased by this amount, or in other words the weight of the yarn is increased in proportion to the square root of the counts and also the fineness of the set and picks is reduced by formula XXX. to compensate for the extra thickness of warp and weft, the counts of yarn and number of ends and picks per inch thus obtained, are such that they will produce a new cloth of the exact weight required and of the same relative balance of structure, but *not of fineness* in texture, since increased weight necessarily involves increased coarseness and *vice versa* so long as the weave structure remains constant. The solution of the foregoing example as given below will assist in making the subject clearer.

Then, to increase the weight of the cloth $\frac{1}{6}$, requires a lower count.

Let x = the required count.

Then as 7 units of weight : 6 units of weight : : $1\sqrt{49}$: $1\sqrt{x}$

Or as 7^2 : 6^2 : : 49 : x

$$\therefore x = \frac{49 \times 6 \times 6}{7 \times 7} = 36\text{s count.} \quad \text{Ans.}$$

With 49s yarn, the original cloth contained 84 ends and picks per inch, but with 36s yarn the threads of warp and weft must necessarily be less in proportion to the square roots of these counts as by formula XXX.

Thus $\frac{84 \times \sqrt{36}}{\sqrt{49}} = 72$ threads per inch.

NOTE.—The square roots of the original counts and of the required counts are in the exact ratio of the required weight to given weight and these conditions are maintained in all examples of this class, consequently the simplest expression of the formula is as follows :—

FORMULA XXXIV.

(a) $\frac{\text{Original counts} \times \text{square of original weight}}{\text{Square of required weight}} = \text{Required counts.}$

(b) $\frac{\text{Original Set} \times \text{original weight}}{\text{Required weight}} = \text{Required Set.}$

As an aid to memory it might be noted that in each case the products of the *originals* are equal to the corresponding products of the *required*.

Example 8.—A cloth is made with 1/30s cotton warp and weft ; it contains 90 ends and picks per inch. Assuming that it is required to produce a new texture which shall retain the same relative balance of structure but to be $\frac{1}{10}$ lighter, what counts of yarn and ends and picks per inch will be required ?

By formula XXXIV.,

(a) $\frac{30 \times 10 \times 10}{9 \times 9} = 37\frac{1}{27}$ counts.

(b) $\frac{90 \times 10}{9} = 100$ ends and picks.

(4) Simultaneous Change of Weight and Fineness.

Example 9.—A cloth is made from 2/36s Botany warp and weft and woven in the $\frac{2}{2}$ twill. It contains 15 twills per inch being constructed according to theoretical conditions. It is required to produce a lighter cloth but containing the same number of twills per inch. Find the required alteration in the set together with the changes in the yarn and weight of fabric that would be involved if the same balance of structure be maintained.

Assume that the $\frac{3}{3}$ twill design be used,

Then since the $\frac{2}{2}$ twill design contains 15 twills per inch which equals $15 \times 4 = 60$ ends per inch.

Also the $\frac{3}{3}$ twill contains 15 twills per in. $= 15 \times 6 = 90$ ends per in.

Further the $\frac{2}{2}$ twill contains $15 \times 4 = 60$ ends per in. $\Big\}$ = 90 diameters per inch.
.. | .. $15 \times 2 = 30$ intersections ,, $\Big\}$

and the $\frac{3}{3}$ twill contains $15 \times 6 = 90$ ends per in. $\Big\}$ = 120 diameters per inch.
... | ... $15 \times 2 = 30$ intersections ,, $\Big\}$

Then since the diameters of threads vary as the square root of their counts and since 90 diameters per inch represents the 2/36s warp and weft.

$\therefore$ As $90 : 120 :: \sqrt{18} : \sqrt{x}$, where x = the required counts.

or $90^2 : 120 :: 18 : x$.

$$\therefore x = \frac{120 \times 120 \times 18}{90 \times 90} = 32\text{s or } 2/64\text{s worsted.}$$

Then to find the relative weights of the two fabrics, let A represent that of the $\frac{2}{2}$ twill cloth and B the $\frac{3}{3}$ twill.

$$\text{Then as } A : B :: \frac{60}{18} : \frac{90}{32}$$
$$\therefore A : B :: 32 : 27$$
$$\text{or } \frac{A}{B} = \frac{\frac{60 \text{ ends}}{18 \text{ counts}}}{\frac{90 \text{ ends}}{32 \text{ counts}}} = \frac{32}{27}$$

i.e. If the first cloth weighed 16 ozs., the second would weigh $13\frac{1}{2}$ ozs. and contain the same number of twills per inch.

(5) Simultaneous Change of Weight and Weave.

Example 10.—Given 2/36s warp and weft, or 35s lea, woven in a $\frac{2}{2}$ twill with 60 ends and picks per inch, it is required to change to $\frac{3}{3}$ twill and increase the weight $\frac{1}{6}$, find the counts of warp and weft, and ends and picks per inch.

(1) Find yarns and set for increased weight of $\frac{1}{6}$.

By Formula XXXIV.

$$\text{Then counts of warp and weft} = \frac{18 \times 6 \times 6}{7 \times 7} = 13{\cdot}2$$

$$\text{And set and picks} = \frac{60 \times 6}{7} = 51\tfrac{3}{7}.$$

(2) Find increase in set due to changing from $\frac{2}{2}$ to $\frac{3}{3}$ twill = 8 to 9. See formula XXXII.

$$\text{Then set and picks} = \frac{51\frac{3}{7} \times 9}{8} = 57\tfrac{6}{7}.$$

This number of ends and picks increases the weight $\frac{1}{8}$ more than required, which, while it retains the same balance of structure, must be reduced by this amount to bring it to the required increased weight. See Formula XXXIV.

(3) Find yarns and set for reduced weight of $\frac{1}{8}$.

By Formula XXXIV.

$$\text{Then counts of warp and weft} = \frac{13{\cdot}2 \times 9 \times 9}{8 \times 8} = 16{\cdot}7$$

$$\text{And set and picks} = \frac{57\frac{6}{7} \times 9}{8} = 65.$$

The whole may be simplified and stated thus :—

1. Counts of warp and weft $= \frac{18 \times 6 \times 6}{7 \times 7} \times \frac{9}{8} \times \frac{9}{8} = 16{\cdot}7$

2. Set and picks $= \frac{60 \times 6}{7} \times \frac{9}{8} \times \frac{9}{8} = 65.$

EXERCISES.

1. A cloth is woven with 36s yarn, in 18s reed 4s. It is required to reduce the fineness of Set to 58 ends per inch. What count of yarn is required ?

Ans., 24s.

2. A woven texture is made with 72 ends and picks per inch in a twill weave of which the first pick is given herewith $\frac{3}{2}\,1$. It is required to change the plan to the following $\frac{2}{4}\,\frac{2}{3}\,\frac{1}{1}$. Assuming that the counts of warp remain constant, what number of ends and picks per inch will retain the same relative balance of structure ?

Ans., 77·4.

3. A cloth is made from 2/48s yarn in 80s Set. The design contains 5 ends and 2 intersections. It is desired to alter the weave to 3 ends and 2 intersections but to retain the same Set. What two-fold counts of yarn will produce a new fabric with the relative balance of structure ?

Ans., 2/68.

4. A cloth is made with 25s yarn in 72s Set. What counts of yarn and Set would be required to make it $\frac{1}{5}$ heavier ?

Ans., $17\frac{13}{36}$; 60.

5. If a cloth is made 70 threads per inch of 25s line, and it is required to make one with 16s lea, how many threads per inch will be required to maintain the same balance of structure.

Ans., 56.

6. Given the same size of yarn, width and length of cloth ; find the relative set and weights of cloths for the following standard weaves :—

(a) plain,
(b) prunelle,
(c) Broken 4 end twill,

(d) regular 4 end twill $^{2}/_{2}$,
(e) regular 3/3 or 6 end twill.

Ans., 60 ; 72 ; 75 ; 80 ; 90.

7. Assume a $^{2}/_{2}$ twill fabric is made from 35s counts of warp and weft with 60 ends and picks per inch ; it is required to change to $^{3}/_{3}$ twill and retain the same No. of twills per inch and balance of cloth structure. Find the set and picks, counts of yarns and relative weight of the two cloths.

Ans., 90 ; 70s ; 4 to 3.

8. A worsted fabric is made from 1/15s warp and weft, and contains 64 ends and picks per inch. If the yarn is changed to 18s Y. S. woollen, how many threads per inch warp and weft are necessary to retain the same relative balance of structure ?

Ans., 47·4.

9. A worsted cloth is made from 2/50s and contains 72 ends per inch. It is required to make a cloth possessing the same relative balance of structure from 2/60s cotton, what number of ends are required ?

Ans., 96.

10. If a cloth is woven in a 54 Set Bradford or 12^{00} Belfast, with a twill design which contains 8 ends and 4 intersections, what number of ends per inch will be required if the counts remain the same but the weaving is altered to 12 ends and 4 intersections ?

Ans., $67\frac{1}{2}$; 13^{50}.

11. A woollen cloth is made with 23 Y. S. in $7\frac{7}{8}$ Portie Leeds, the weight of the cloth is 16 ozs .per yard. It is required to produce a similar cloth weighing 14 ozs. per yard. Find the counts of yarn and Set.

Ans., 30 ; 9.

12. Given a cloth woven with 2/36s Botany warp and weft, 60 ends and picks per inch, cassimere twill, change the weave to $^{3}/_{2}$ twill and decrease the weight $\frac{1}{7}$. Find the Set and picks, and counts of warp and weft.

Ans., 80·3 ; 28·1 or 2/56.

13. A worsted fabric is composed of 2/40s warp and 1/32s weft. There are 64 ends and 56 picks per inch. What counts of warp and weft, and ends and picks per inch will be required to produce a new cloth of the same relative structure but $\frac{1}{4}$ heavier ?

Ans., $12\frac{4}{5}$; $20\frac{12}{25}$; $51\frac{1}{5}$; $44\frac{4}{5}$.

14. A finished woollen cloth weighing $23\frac{3}{4}$ ozs. per yard, 36″ by 56″, counts 38 ends and 36 picks per inch. It is required to reduce the weight to $22\frac{1}{4}$ ozs. per yard. Find the relative counts of yarns, ends and picks per inch, which the required cloth should contain so as to retain the same relative balance of structure. If for temporary and economic reasons the warp and weft threads are decreased to 34 ends and picks per inch finished, and the yarn modified to produce the above required weight, prove that such alterations are theoretically wrong.

15. Required the counts of warp and weft when a cloth made from 2/60s cotton and woven in 54s set Stockport is required to be increased in fineness of pitch $\frac{1}{2}$.

Ans., 2/135.

16. If a cloth is made 70 threads per inch of 25s twist cotton, and it is required to make one with single 16s yarn, how many threads per inch will be required to maintain the same balance of structure ?

Ans., 56.

17. Given a plain linen cloth containing 40 ends and picks per inch of 30s lea warp and weft, it is required to change to a 3 end twill and increase the weight $\frac{1}{4}$, find the counts of yarn, and ends and picks per inch necessary to retain a corresponding balance of structure.

Ans., 27·6 ; 46.

18. Required a range of linens in 6/7 ; 7/8 ; 8/9 ; 9/10 ; 10/11 and 11/12 Sets and picks (40″ scale and 37″ glass), find the nearest suitable lea counts of warp and weft for each of the above cloths, assuming that the 6^{00} set and 7 shots per

37″ glass is woven with 16s lea warp and 20s weft.

Ans., 22/26 ; 28/33 ; 36/40 ; 44/49 ; 54/59
Nearest whole number.
say 20/25 ; 30/35 ; 35/40 ; 45/50 ; 55/60
Nearest standard lea number.

19. If 7/9 is made from 25/30, what yarns will make 11/13 ?

Ans., 61·75 ; 62·6, say 60/65.

20. If 11/13 plain linen is made from 55/90, what yarns would be put into 11/13, 5 end satin, to maintain the same balance of cloth ?

Ans., 27 ; 44.

CHAPTER XIV.

The Construction of Woven Fabrics. C. Angle of Curvature Considered.

Immediately the angle of curvature is taken into consideration it is found that the number of threads of warp or weft which the fabric can naturally contain will vary with that angle.

Experimental research and experience demonstrates that the angle of curvature which the warp and weft threads form with each other is a factor of considerably more importance than appears to the casual observer. It not only modifies the number of warp and weft threads which the finished cloth must contain but it is very important in developing certain features of many woven fabrics, both in single and double plain weaves.

As an aid in determining the variations of curvature, it is necessary to select a typical method of interlacing, for which purpose the ' plain weave ' is chosen. This is because it serves as a basis for the construction of woven fabrics in other weaves, and further, whether the texture be single, double, or multiple, there is constantly a large number of woven fabrics produced in which the variation of angle is a prevailing characteristic.

Example 1.—Assume the diameter of the warp and weft to be $\frac{1}{60}$ of an inch each. Find the correct number of ends and picks which a fabric will contain under

natural conditions, *i.e.*, when the two sets of threads are as close to each other as their diameters and angles will permit.

This is illustrated at Fig. 5, which is a cross section through the warp. In this case each set of threads forms equal angles. A consideration of the figure shows that the angle formed by the weft at any point of the intersection is a continually changing one.

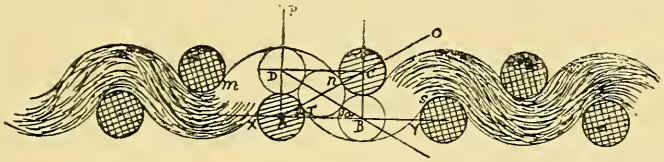

Fig. 5.

Straight lines drawn through the centre of the weft thread at B, its lowest position on the under side of the fabric, and through D, its highest position on the upper side, distinctly demonstrate that the average angle formed by the weft with the horizontal is one of 30°, and consequently, the angle of the warp will be 30° since they each form equal angles.

Any attempt to increase the natural number of warp or weft threads will cause a decrease in the relative number of the opposite set of threads as well as a decrease in the angle of curvature in those threads, *e.g.* if one set of threads be made to lie perfectly straight, the opposite set will produce an angle of 45°, that is assuming the threads are put as close together as the angle of curvature will permit (see Fig. 8).

If the warp lies perfectly straight the weft may, and occasionally does, in practice produce an angle

of 30°. In such cases the fabric is not woven as close as the diameter, etc., permits. The warp and weft threads can each form equal angles of less than 30°, but then the cloth will be looser in proportion which may or may not be detrimental, according to the class of material which is being made, and the purpose it is intended to serve. When an angle less than 45° is desired, it is frequently advisable to use a looser spun yarn as is often done in the manufacture of dress goods, wherea mule spun is used in preference to a throstle spun yarn, as it has a relatively greater diameter, and it also produces a fuller and softer handle together with a lighter cloth.

The following is a description of the construction of Fig. 5. Upon the horizontal line X Y, of any length, take any point A and describe a circle representing a cross section of the warp. With the same centre and radius of A + diameter of weft, describe an arc M N; draw a perpendicular line P A meeting X Y in the centre of thread A; from point A draw A O, making an angle of 30° with A B; then, upon the straight line A O, describe a circle C of the same radius as A and so that its periphery shall touch the arc M N at N, the point where M N and A O intersect. From C draw a line at right angles to X Y, meeting X Y at B, and from C draw a line at right angles to C B, joining A P in D; then from centre of thread C describe an arc of the circle R S with radius C + diameter of the weft. The sides A B C D now form a perfect rectangle, and a straight line drawn through the centres of the weft at B and D reveals the angle formed by the weft to be one of 30°. It is now

necessary to find the distance from A to B or D to C which represents the amount of space that one warp thread plus one intersection of the weft must occupy in the woven piece.

By construction, we know that the distance from A to C equals two diameters (1 warp + 1 weft), as does also the distance from B to D being diagonals of the same rectangle. Assuming the diameter of warp and weft threads to be $\frac{1}{60}$ of an inch, then the distance B D $= \frac{1}{60} + \frac{1}{60} = \frac{1}{30}$ of an inch, and distance A D equals half the diameter of the warp and half the diameter of the weft, $= \frac{1}{120} + \frac{1}{120} = \frac{1}{60}$ of an inch. If $x =$ length of A B (base), then by proposition 47, Book 1, "Euclid," we know that the sum of the squares on the sides (A D + A B) equals the square on the hypotenuse B D. Thus, $A\,D^2 + A\,B^2 = B\,D^2$

$$= \left(\tfrac{1}{60}\right)^2 + x^2 = \left(\tfrac{1}{30}\right)^2$$

$$\therefore \quad x^2 = \left(\tfrac{1}{900} - \tfrac{1}{3600}\right) \text{ or } \tfrac{1}{1200}$$

$$\therefore \quad x = \sqrt{\tfrac{1}{1200}} = \tfrac{1}{34 \cdot 64} \text{ of an inch.}$$

The same result may be obtained upon the well known theory of trigonometrical ratios.

Let $x =$ the distance A B. Commencing with the knowledge that the cosine of angle in any right angle triangle is always equal to the base ÷ hypotenuse, and that the hypotenuse is always opposite the right angle, the perpendicular is always opposite the angle under consideration and the base is always opposite the complement of this angle.

Then in the triangle A B D

$$\frac{\text{Base}}{\text{Hypotenuse}} = \frac{A\,B}{B\,D} = \text{cosine of angle A B D} = 30°$$

And cosine of an angle of 30° $= \frac{\sqrt{3}}{2} = \frac{AB}{BD} = \frac{x}{\frac{1}{30}}$

$\therefore x = \frac{\sqrt{3}}{30 \times 2} = \frac{1}{34 \cdot 6}$ as previously.

By adopting the trigonometrical method any problem of this kind can be most readily and correctly solved.

If these results are compared with those worked out by the first rule given in chapter XII., formula XXIX., where the angle of curvature was ignored, it will be observed that by this latter method an additional 4·64 threads per inch are obtained. By formula XXIX. the cloth was found to contain 30 threads of warp plus 30 intersections of weft per inch. From the foregoing we may easily find the relative space which 1 warp thread plus 1 intersection of weft will always occupy, so that the process of finding the Set for fabrics woven under conditions as shown at Fig. 5 may be very much shortened. Thus, by the first method, 1 warp thread plus 1 intersection of weft $= \frac{1}{30}$ of an inch, and by the second method 1 warp thread plus 1 intersection of weft $= \frac{1}{34 \cdot 64}$ of an inch. Therefore the two units of space relatively occupied by the latter will be in the following ratio :

$$\frac{\frac{1}{34 \cdot 64} \times 2}{\frac{1}{30}} = \frac{30 \times 2}{34 \cdot 64} = 1 \cdot 732$$

FORMULA XXXV.

Angle of Curvature of 30° considered.

$$\frac{\text{No. of dia. of threads per inch} \times \text{ends in 1 repeat of design.}}{(\text{No. of intersections} \times 1 \cdot 732) + \text{No. of ends more than intersections in 1 repeat of design.}}$$

= Ends or picks per in. which the finished fabric should contain.

which, when applied to the above example

$$= \frac{60 \times 2}{(1{\cdot}732 \times 2) + 0} = 34{\cdot}64 \text{ threads per inch.}$$

As a proof that the foregoing agrees with practice take the following example which represents the make of a typical light fancy worsted coating :

Example 2.—

Warp and weft 2/40s worsted.

Ends and picks per inch in loom, 48.

Weave plain as Fig. 5. Reed width 60 inches.

Finished width 54 inches.

Ends and picks per inch finished, 53 to 54.

PROOF. $2/40 = 20s = \frac{1}{9\frac{1}{5}}$ diameter.

$\therefore$ Ends and picks per inch

$$= \frac{95 \times 2}{(2 \times 1{\cdot}732) + 0} = 54.$$

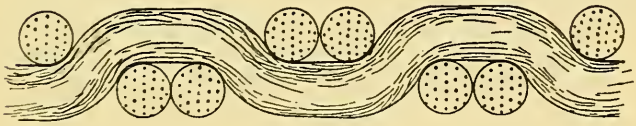

Fig. 6.

Both this and formula XXIX are applicable to all classes of woven fabrics which are of a regular character and where warp and weft each form angles of 30°. Formula XXIX only gives approximate results, whilst XXXV yields very accurate results.

The greatest difference obtained by the two methods is when the number of intersections in one repeat of the pattern is equal to the number of threads in the same repeat. But this difference gradually decreases

as the number of threads in one repeat of the pattern increases over the number of intersections.

Example 3.—Consider Figs. 6 and 7, which are sections through the warp of the 2-and-2 and 4-and-4 twill respectively.

In each case the angle formed by the warp and weft at the points of intersection is one of 30°.

By formula XXIX.

Fig. 6 .....$[60 \times 4] \div [4 + 2] = 40$

Fig. 7 .....$[60 \times 8] \div [8 + 2] = 48$

By formula XXXV.

Fig. 6 .....$[60 \times 4] \div [(2 \times 1{\cdot}732) \div 2] = 44$

Fig. 7 .....$[60 \times 8] \div [(2 \times 1{\cdot}732) + 6] = 50$

Observe the relative increase in Fig. 6 $= 40 \div 44 = 0{\cdot}9$, which indicates a difference of 10 per cent.; whilst in Fig. 7, $48 \div 50 = 0{\cdot}96$, which shows a variation of 4 per cent.

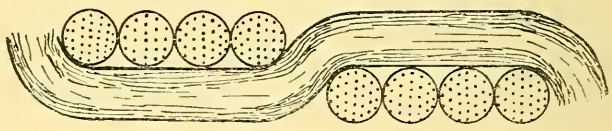

Fig. 7.

The chief factors which cause the two sets of yarns to produce unequal angles in a fabric may be enumerated as follows :—

1. A difference in the diameters of the two yarns, in which case their relative bending powers would be in the ratio of the cubes of their diameters, other factors remaining constant.

2. A variation in their relative powers of resistance, due to a difference in quality or material.

3. The weave structure.

4. The construction of the fabric so that it shall contain relatively more threads of one set than of the other set, warp or weft, than would be obtained by the application of the principle involved in formula XXXV. previously demonstrated.

WARP STRAIGHT, WEFT BENDING, AND VICE VERSA.

In proceeding, we shall now consider the principle underlying the construction of those fabrics in which one set of threads lie perfectly *straight*, while the other performs all the bending.

An illustration of the structure of such a fabric is shown by a cross section through the warp at Figure 8.

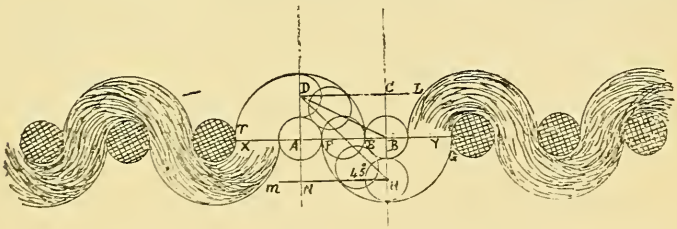

Fig. 8.

An examination of the construction of this diagram not only shows the warp threads to lie in a perfectly straight line, while the weft does all the bending, but it also reveals the average angle of inclination to be 45°, *e.g.* Take any point X and draw from X a straight line X Y, but unlimited towards Y.

In X Y take any point A, then with A as centre and radius equal to half the diameter of warp, describe a circle representing the diameter of the warp ; again, with A as centre and radius equal to half the diameter

of the warp plus one diameter of weft, describe a semi-circle meeting X Y in T and E respectively. Further, in X Y take a point B at a distance from E equal to the radius of the circle circumscribing point A. Then with B as centre and radius E B, describe a circle to represent the second warp thread. Further, with B as centre and radius A T or A E, describe a second semi-circle so as to meet X Y in the points F and G (repeat the process to show a greater length of weft interlacing with the warp). Then to show the average inclination of the weft proceed as follows :—

From the points A and B draw perpendicular lines to the centre of the weft thread in its highest and lowest position, *viz.* : D and H respectively ; then from the points D and H draw straight lines D L, H M unlimited towards L and M respectively and each parallel with X Y or A B.

Produce D A to meet H M in the point N, also H B to meet D L in the point C.

Then because the side A D equals the side B H (each being equal to half the diameter of the warp plus half the diameter of the weft), and also B C and A N being equal (each meeting parallel lines with A B and of equal distances from A B), then the sides D A and A N are together equal to the sides C B and B H.

Further, because the straight line A B equals two diameters, *viz.*, half the diameter of warp plus one diameter of weft plus half the diameter of warp (A F + F E + E B), therefore A B equals D N or C H, and because A B equals D C or N H, therefore D C and N H are each equal to the sides D N or C H.

Again, because the angle D A B is a right angle (construction), and since the straight line D N falls upon the parallel lines X Y and M H, the interior angle D N H is equal to the exterior angle D A B or D A Y ("Euclid" I, 28).

Join H D (the lowest and highest positions of the centre of the weft thread), then the line H D which represents the average angle formed by the curvature of the weft makes an angle of 45° with the horizontal line X Y or A B.

PROOF.—In the triangle D N H, because sides D N, N H are equal to each other (proved) the triangle D N H is Isosceles, therefore the angles N D H, D H N at the base D H are equal, and since the three interior angles of a triangle are together equal to two right angles, Euclid I., 32, and the angle D N H is a right angle (proved) therefore angles D N H, D H N are together equal to

$$180° - 90° \text{ (D N H)} = 90°$$

$$\therefore \text{ Angle N H D} = \frac{90°}{2} = 45°.$$

From the construction of the foregoing example it will be clearly manifest that the distance apart of the warp threads at each intersection is equal to one diameter of warp plus one diameter of weft, *viz.*, $\frac{1}{60} + \frac{1}{60} = \frac{1}{30}$ or 30 threads of warp per inch (assuming the diameter of the warp and weft threads to each equal $\frac{1}{60}$ part of an inch as in the previous examples).

The number of weft threads per inch that would be contained in a fabric constructed under such conditions

would be equal to the denominator of the fractional part of one thread in inches, because if the warp threads lie straight the weft threads would touch each other.

Further, it is interesting to note that the average angle produced by the weft remains unchanged whatever be its thickness, providing the warp lies perfectly straight.

This truth is clearly illustrated at Figure 9. In this example the diameter of the warp is represented as before, *viz.* : $\frac{1}{60}$ of an inch, while the thickness of the

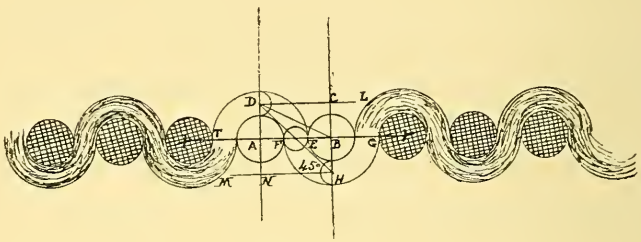

Fig. 9.

weft is reduced to $\frac{1}{120}$ of an inch. The diagram (Fig. 9) is constructed in the same way as Figure 8. The same letters in each diagram refer to corresponding parts and the subsequent reasoning is identical in each case, consequently it is not necessary to repeat here the process of construction and reasoning.

The setting of the fabric in this case equals $\frac{1}{60} + \frac{1}{120} = \frac{1}{40}$ or 40 warp threads per inch, and 120 weft threads per inch.

Each of the foregoing examples, including any change in weave, may be reduced to and solved by the application of the following formulæ :—

FORMULA XXXVI. Applies to the Set of threads which are perfectly straight in the finished fabrics, and is as follows :—

$$\frac{\text{Total dia. straight thds.} + \text{total dia. interlacing thds. in 1 rpt. des.}}{\text{Number of threads in one repeat of design}} = \text{The fractional part of one inch which each straight thread in the finished fabric should occupy.}$$

And this applied to the last example equals

$$\frac{\frac{2}{60} + 1\frac{2}{20}}{2} = \frac{1}{40} \quad \therefore \quad 40 \text{ threads per inch.}$$

FORMULA XXXVII. Applies to the Set of threads which perform all the bending in the finished fabric and is as follows :—

The denominator of the diameter of the bent thread = the number of threads per inch, thus :—

In the above example, diameter of weft $= 1\frac{1}{20}$.

$\therefore$ Threads per inch equal 120.

The explanations given in connection with formulæ XXXVI. and XXXVII. are especially applicable to ribs, glacies, and dressed face fabrics. The latter formula includes all cloths produced from a sateen basis in which the warp or weft is the predominant surface factor.

Example 4.—A 15 shaft corkscrew cloth is required to be made from 2/48s Botany warp and 1/30s Botany weft. The diameters of the warp and weft are $\frac{1}{104}$ and $1\frac{1}{17}$ respectively. Find ends and picks per inch.

Therefore, the Set by formula XXXVII.= 104 and 117 threads per inch respectively of warp and weft.

UNEQUAL ANGLES OF CURVATURE.

Suppose now the two sets of threads undergo a

change such that they shall form *unequal* angles. For convenience let us assume that the angle formed by the warp has been increased to 45°. The number of threads will necessarily increase while the angle formed by the weft will decrease to 22·5°.

The principle which underlies this theory is demonstrated if we consider the construction of Figure 10 and the solution of the problems connected therewith. Construction:—Take any suitable point X and draw a horizontal line X Y. In X Y take any point A and describe a circle representing the diameter of the warp.

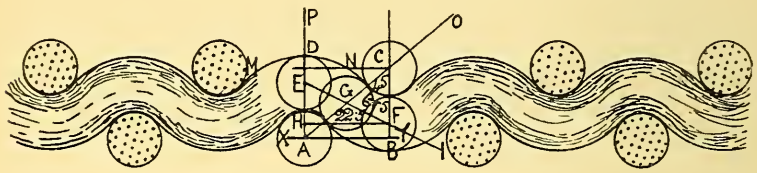

Fig. 10.

From centre of circle A draw a straight line A P perpendicular to X Y, and also from the same centre draw a straight line A O making an angle of 45° with A Y.

With A as centre and radius equal to the radius of circle A plus 1 diameter of weft, describe an arc of a circle M N.

In A O take a point C, equal in distance to the radius of circle A, from the arc M N at the point where A O passes through M N and describe a circle C, so that its circumference touches the periphery of the arc M N.

Through the centre of circle C draw two straight lines parallel to A Y and A P and cutting A P in D and

A Y in B respectively. Then to find the angle produced by the weft, find the centre of the weft threads in the lines C B at F; A D at E and A C at G. Join E G F and produce F to I.

From the point F draw a straight line parallel to A B cutting A D in the point H, then the line E F produced to I represents the average inclination of the weft thread with the horizontal line F H or X Y to be one of 22·5°.

PROOF.—In the triangle A B C,

Angle C A B = 45° by construction.

Angle A B C = 90° by construction.

∴ Angle B C A = 180° − (90° + 45°) = 45°.

In the triangle G F C,

The side C G = ½ diameter of warp + ½ diameter of weft,

and ,, C F = ½ ,, ,, + ½ ,, ,,

∴ ,, C G = the side C F.

∴ The triangle G F C is Isosceles and the angles at the base of an Isosceles triangle are equal (Euclid I. v.) and further the combined angles C G F and C F G are together equal to 2 right angles minus angle G C F or 180° − 45° (G C F) = 135°.

∴ The angles C G F and C F G each equal $\frac{135}{2}$ = 67·5.

Further, the angle H F C is a right angle (construction) of which the angle G F C forms a part. ∴ The angle H F G = (90° − G F C) 90° − 67·5° = 22·5°, which represents the angle produced by the weft with the horizontal H F.

The length of the straight line A B represents the space occupied by one warp thread plus one intersection

of weft, and since there are as many intersections of the weft as there are warp threads, the number of such distances (A B) which are contained in one inch represents the number of warp threads per inch which the finished fabric would contain, *e.g.*, Distance A C = 1 diameter of warp plus 1 diameter of weft (construction)

$$= \tfrac{1}{60} + \tfrac{1}{60} = \tfrac{1}{30} \text{ inch.}$$

Let x = distance A B.

Since angle C A B is one of 45°

and $\dfrac{\text{Hypotenuse}}{\text{Base}} = \dfrac{\text{A C}}{\text{A B}}$ = Secant of angle C A B

$$= \text{Secant } 45^\circ = \frac{\sqrt{2}}{1}$$

$$\therefore \frac{\text{A C}}{\text{A B}} = \frac{\sqrt{2}}{1} = \frac{\frac{1}{30}}{\frac{x}{1}} = \frac{1}{30x}$$

$$\therefore \frac{1}{x} = \frac{\sqrt{2} \times 30}{1}$$

and $$\frac{1}{x} = \frac{2 \times 30 \times 30}{1} = \frac{1800}{1}$$

$$\therefore x = \sqrt{\tfrac{1}{1800}} = \tfrac{1}{42{\cdot}4} \text{ inch.}$$

Therefore No. of warp threads+intersections of weft equal 42·4 threads per inch, which shews an increase of (42·4 − 34·64) = 5·76 threads per inch when the angle formed by the warp is 45° and the weft 22·5, instead of 30° as previously considered.

In the next example assume the angle formed by the warp to increase from 45° to 60° (see Fig. 11).

A further decrease in the angle produced by the weft will readily be observed, it being now 15° (Fig. 11) instead of 22·5° as in Fig. 10. The angle of 60° may

be taken as the limit of curvature which either set of threads can make in single cloths and when both sets of threads form enequal angles.

CONSTRUCTION :—Take any suitable point X and draw a horizontal line X Y unlimited towards Y. In X Y take any point A and with A as centre and radius equal to half the diameter of the warp, describe a circle which shall represent the diameter of the warp. From the centre of circle A, draw a straight line A P perpendicular to X Y and unlimited towards P, also from the same centre draw a straight line A O unlimited towards O, and making an angle of 60° with A Y. Further, with A as centre and radius equal to the radius of circle A, plus one diameter of the weft, describe an arc of a circle M N.

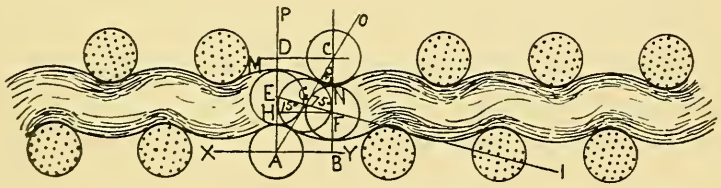

Fig. 11.

In A O take a point C equal in distance to the radius of circle A from the arc M N at the point where A O passes through M N and describe a circle such that its circumference touches the periphery of M N. Also from the centre of circle C draw two straight lines parallel to A Y and A P cutting A P in D, and A Y in B respectively.

Then to find the angle produced by the weft, find the centre of the weft thread in the lines C B at F ;

A D at E ; and A C at G. Join E G F and produce F to I.

From the point F draw a straight line parallel to A B and meeting A D in the point H. Then the straight line E F produced to I represents the average inclination of the weft thread with the horizontal line F H or X Y which will be found to be one of 15°.

PROOF.—In the triangle A B C,

Angle A B C = 90° by construction.

,, C A B = 60° ,, ,,

,, A C B = 180° − (90° + 60°) = 30°.

And in the triangle G C F,

The side G C = ½ dia. of warp + ½ dia. of weft (construction),

and ,, F C = ,, ,, ,, ,,

∴ The side G C = the side F C.

∴ The triangle G F C is Isosceles, and the angles at the base of an Isosceles triangle are equal.

Then because the three interior angles of a triangle are together equal to two right angles, the angles C G F and C F G are together equal to 180° − 30° (G C F) = 150°.

Therefore the angles C G F and C F G are each equal to $\frac{150}{2} = 75°$.

Further the angle H F C is a right angle (construction) of which the angle C F G forms a part.

Therefore the angle H F G = 90° − 75° (G F C) = 15° which represents the average angle produced by the weft with the horizontal line H F or X Y when the warp forms an angle of 60°.

The length of the straight line A B indicates the fractional part of an inch which one diameter of warp

plus one intersection of weft occupies in the finished piece, consequently the denominator of such fraction represents the number of warp threads per inch which the fabric would contain.

The following is a solution of the problem.

Distance A C $= \frac{1}{60} + \frac{1}{60} = \frac{1}{30}$ of an inch.

Let x = distance A B in inches.

And since the angle C A B is one of 60°

$$\frac{\text{Base}}{\text{Hypotenuse}} = \frac{\text{A B}}{\text{A C}} = \text{Cosine of angle C A B.}$$

$$\text{Cosine of } 60° = \tfrac{1}{2} = \frac{x}{\frac{1}{30}} = 30x.$$

$$\therefore \quad x = \frac{1}{2 \times 30} = \tfrac{1}{60} \text{ part of an inch.}$$

Consequently if a cloth is to be made under conditions such as above it must contain 60 threads of warp per inch and the number of weft threads per inch would be rather less than is represented by 1 diameter of warp plus 1 diameter of weft, inasmuch as the weft is somewhat bent out of the straight line.

These two examples, Figures 10 and 11, have been selected to demonstrate the theory, that as the angle increases the cloth must contain relatively more threads of warp or weft per inch, or, inversely, an increase in the number of warp or weft threads causes a relatively greater angle of curvature in the respective set of threads in which the increase takes place.

EXERCISES.

1. A dressed face union cloth is required to be produced from 2/36s cotton and 10s Y.S. woollen. Find set and picks per inch. Diameters $\frac{1}{111}$ and $\frac{1}{73}$. *Ans.*, 30; 43.

2. A 13 shaft corkscrew is required to be produced from 2/36s worsted warp and 1/20 worsted weft. Find a suitable number of ends and picks.

Ans., 85 ; 95.

3. A $\frac{2}{2}$ warp rib cloth complete on 2 ends and 4 picks is required to be made from 60/2 spun silk warp and weft. The former produces all the bending while the latter is perfectly straight. Find a suitable number of ends and picks. Diameter $= \frac{1}{206}$.

Ans., 206, 137.

4. An aeroplane linen cloth weighs $3\frac{1}{2}$ ozs. per sq. yard, it counts 90 ends by 94 picks per inch of cloth. The lea numbers of the yarns in the boiled state including size are 90s warp and 110s weft. The average strength per inch of cloth is 110 lbs. warp and 100 lbs. weft.

(a) If it is desired to produce a cloth of similar balance of structure but weighing 3 ozs. per sq. yard, what corresponding yarns and set must be employed.

(b) Find the actual diameter of the yarns in the boiled state, and ascertain if the fabric has been set in accordance with theory when the warp and weft form equal angles.

(c) Based on the theory that the strength of yarns and cloth varies inversely and pro rata to the counts of yarns and the weight of fabrics, calculate the load resistance in lbs. per inch width for the 3 ozs. cloth.

(d) Find the spun yarn numbers for both of the above cloths, when the estimated loss due to boiling is 18% for warp and 25% for weft, and the increase due to sizing is 3%.

Ans., (a) 122·5/150 ; 105/110 ; (b) $\frac{1}{152}$, $\frac{1}{166}$;

$$\text{actual} \atop \text{theory} \quad \frac{\overset{\text{set and picks}}{90+94}}{91\cdot6+91\cdot6} = \frac{184}{183\cdot2}$$; (c) 94, 86 lbs. ;

(d) 76/83 ; 100/112 or 75/85 ; 100/110.

CHAPTER XV.

Conditioning; or the Standard Allowance of Moisture in Textile Materials.

The fibres composing yarns, and all articles manufactured from wool, cotton, flax, silk and every other textile material under normal conditions contain a certain amount of moisture. This hygroscopic propensity is of such a character that under favourable conditions these materials will rapidly absorb additional moisture when exposed to dampness, and even take up in considerable quantities water that may be sprinkled upon them artificially; on the contrary, when exposed to dry air, natural or artificial, they lose with corresponding rapidity much of their natural moisture, consequently, the relative weight of any material is repeatedly changing with the temperature of the air in which it is exposed. These varying factors are necessarily a constant source of inconvenience and trouble to dealers, spinners, and manufacturers.

Take as an example the reeling of silk in Japan, which commences with the rainy season. It is difficult to estimate correctly the amount of moisture which the silk fibre has absorbed during the ocean transit, in addition to the amount absorbed in the damp climate of Japan. Subsequently the material loses a considerable amount of moisture and therefore weight during its passage through the several processes of preparation into yarn, and of manufacture into

fabrics, with the result that the manufacturer is apt to err in his calculation of the cost of the raw material. The wool fibre has possibly the greatest affinity for moisture. It is capable of absorbing and retaining water to an extent which is slightly over $\frac{1}{3}$ of its absolute dry weight, or an increase of about 35%.

It was in the silk industry where the question of "condition" was first seriously considered, possibly on account of its relatively greater value than other textile fibres.

In October of the year 1750, an establishment was founded at Turin to test the "CONDITION" of silk from which the term "CONDITIONING" originated. To-day, CONDITIONING HOUSES are common in all the leading centres of the textile industry; many spinners and manufacturers have their own conditioning apparatus.

The object of a conditioning house is to test the amount of moisture contained in raw material, yarn, or fabric, and afterwards, to compare with the official standard allowance for moisture the material which has been tested.

Elaborate tests extending over a series of years have been made by persons engaged in the trade, and their conclusions demonstrate that after absolute dryness has been obtained, regain of moisture will take place on exposure to the average temperature of the climate of the country, usually in a warehouse. The various materials will regain different percentages according to the nature of the material which is tested. These regains have been tabulated, officially acknowledged, and fixed as the standard amount of moisture

which the respective materials must contain as commercial articles.

The following table shows the standard allowances of moisture or amount of regain for the several textile fibres used in this country.

TABLE V.

Raw wool	amount of regain	16%	direct loss	13·77%
Combed tops in oil,	,,	,,	19%	,,	16·01%
Combed tops, dry,	,,	,,	18¼%	,,	15·43%
Noils,	,,	,,	14%	,,	12·3%
Yarn and fabrics ,	,,	,,	18¼%	,,	15·43%
Silk, all processes,	,,	,,	11%	,,	9·86%
Cotton, all processes,	,,	,,	8½%	,,	7·91%
Flax and Hemp	,,	,,	12%	,,	10·71%
Tow, spun,	,,	,,	12½%	,,	11·11%
Jute,	,,	,,	13¾%	,,	12·09%

The operation of conditioning is simple. The best way is to obtain absolute dryness, then the difference between the original and absolute dry weight reveals the amount of water contained in the material before testing.

The apparatus which is used for the purpose of acquiring absolute dryness consists of an oven about 40 inches high by 30 inches in diameter ; the oven for conditioning silk is 30 inches by 16 inches respectively. Inside the oven is a cylindrical hot air chamber, the distance between the two chambers being about 1½ inches, which allows the hot air to freely circulate all round the inner chamber.

The heat is obtained from a ' Bunsen ' gas burner, which uses about 75 per cent of air, and the lights, about 80 in number, are arranged in a circular form

under the inner oven. A thermometer is arranged so that the bulb reaches half-way down the oven, the degrees of temperature having a range from 10 to 400 Fahrenheit.

A pair of scales is firmly fixed immediately above the oven, so that one arm is directly over the centre of the oven. Suspended from this arm is a small wire which passes through the centre of the cylinder cover, with a reel attached to it for tops or yarns, and a creel substituted for wool, noils, cotton, flax, or loose materials. The balance is in equilibrium when either the reel or creel is attached to this arm, whilst to the opposite arm is suspended the scale pan for the ordinary weights. The measure of deflection or sensibility of the balance should be 1 grain.

For *Wool* the oven may be heated up to 230° F. or 110° Centigrade.

For *Cotton* and *Flax* up to 220° F. or $104\frac{4}{5}$ C. is the limit of temperature to avoid scorching.

For *Silk* the temperature is sometimes maintained as high as 248° F. or 120° C.

In no case must the temperature be less than boiling point 212° F. or 100° C. or the moisture will not be all evaporated.

The method of procedure consists in selecting equal portions of wool from the top, centre and bottom, or from the centre and sides so as to secure a fair sample of the average amount of moisture contained in the bulk. This sample of top is then very accurately weighed, without loss of time, wound on the reel and

placed in the oven suspended from its balance arm. The temperature is increased until it exceeds the boiling point, but it must be kept within the prescribed limits to avoid scorching or discolouring. The period of subjection to heat is variable, frequently 30 to 45 minutes is sufficient, but to fix the time is scarcely possible.

The material being now in the oven and the balance weights adjusted, a change in the weight is soon observed which is due to the moisture that is being driven off. This loss of weight will continue until all the moisture has been dispersed, after which the material should still remain in the oven for 5 or 6 minutes. Then, so long as the temperature in the oven has been maintained above 212°F. or 100°C., the wool may be considered absolutely dry. Provision is made on the same arm to which the reel is fixed for the reception of small weights, which are placed on it as the wool continues to lose weight. These therefore indicate at a glance the moisture which is gradually being lost, whilst the ordinary scale pan retains the original weight.

Then by simple arithmetic we can obtain the amount of moisture per cent. which the material contained, and this, when compared with the standard allowance of moisture for the particular wool tested, readily reveals any excess of moisture which was contained in the material.

When testing yarns, loose wool, noils, silk, cotton, flax, or other material, the same conditions apply, the main object being to obtain for the purpose a fairly representative sample of the bulk.

When a lb. or any number of lbs. of the material can be procured, it simplifies the calculation, otherwise, the most convenient portion of warp, number of hanks of yarn or weight of loose material must be taken and tested as above. When the yarn is in the form of hank, a certain number of hanks are selected; when on spools, tubes or bobbins, it is reeled into the form of hanks, but if warp in the ball, then a convenient number of threads are split off, weighed, reeled and tested in the ordinary way.

The following examples will demonstrate the essential principles and make the subject more clearly understood.

Example 1.—Assume 2 lbs. of combed top, in oil, tested in the conditioning oven; when absolute dry weight has been obtained the direct loss in weight is observed to be 5 ozs. 6 drs. What is (1) the direct loss per cent., (2) the absolute dry weight per cent., (3) the amount of regain necessary to produce the original weight, (4) the excess or loss per cent. of moisture it contained as compared with the standard allowance of 19 per cent.?

(1) *Direct loss per cent.*

Loss on original weight, 5 ozs. 6 drs. = 86 drs.
Original weight = 512 drs.
Dry weight = 512 − 86 = 426 drs.

Then, if loss of moisture on 512 drs. be 86 drs., the loss per cent. therefore equals

As 512 : 100 : : 86 : x

Or, expressed as a formula it would read thus :—

FORMULA XXVI.

$$\frac{\text{Loss on original weight} \times 100}{\text{Original weight.}} = x \text{ or direct loss } \%$$

$$\therefore x = \frac{86 \times 100}{512} = 16{\cdot}8\% \text{ direct loss.}$$

(2) *Absolute dry weight per cent.* $= 100 - 16{\cdot}8 = 83{\cdot}2$.

(3) *Amount of regain* in moisture on 426 drams of absolute dry weight necessary to produce the original weight, 512 drams, equals 86 drams.

∴ Amount of moisture per cent.=

As 426 : 100 :: 86 : x, where x equals the regain per cent., or, expressed as a formula it reads :

FORMULA XXVII.

$$= \frac{\text{Loss on original weight} \times 100}{\text{Absolute dry weight}} = \text{Regain } \%$$

$$= \frac{86 \times 100}{426} = 20{\cdot}19\%$$

(4) *Excess of moisture per cent.* The 100 units of absolute dry weight with a regain of 20·19% equals $100 + 20{\cdot}19 = 120{\cdot}19$ units of weight of the material tested. But the standard allowance is only 19, therefore 100 units of absolute dry weight should equal $100 + 19 = 119$ units of weight commercially, which shews that the excess of moisture in 119 commercial units of weight $= 120{\cdot}19 - 119 = 1{\cdot}19$.

$$\therefore \text{The excess per cent.} = \frac{1{\cdot}19 \times 100}{119} = 1$$

(4a) *Regain.*

Regain allowed on 83·2 at 19 per cent.

$$= \frac{83{\cdot}2 \times 19}{100} = 15{\cdot}8.$$

Then the absolute dry weight per cent. plus the regain officially allowed

$$= \frac{83{\cdot}2 \times (100 + 19)}{100} = 99 \text{ or}$$

83·2 absolute dry weight per cent.
15·8 official allowance on 83·2 units weight.

99 units of weight out of every 100 of the bulk, or 1 unit of weight in excess of moisture on every 99 lbs., which is, practically, 1 per cent.

Example 2.—The standard allowance of regain for noils is 14 per cent. What should be the loss per lb. of moisture, also its loss per cent. and the absolute dry weight per cent. to fulfil the above conditions ?

For convenience, find the gain on 1 lb. dry weight at 14 per cent.

$$= \frac{\text{absolute dry weight} \times \text{regain \%}}{100} = \text{total regain on dry weight.}$$

$$= \frac{256 \text{ drams} \times 14}{100} = 36 \text{ drams regain on 1 lb.}$$

and 256 drs. + 36 drs. = 292 drams.

= The original weight necessary to produce 1 lb. dry weight.

(1) The percentage of dry weight $= \frac{\text{dry weight} \times 100}{\text{original weight.}}$

$$= \frac{256 \times 100}{292} = 87{\cdot}7\% \text{ of dry yarn.}$$

(2) And $100 - 87{\cdot}7 = 12{\cdot}3\% =$ loss of weight in testing.

(3) Then, $\frac{\text{Loss on original weight (1 lb.)} \times \text{loss \%}}{100} =$

$$\frac{256 \text{ drs.} \times 12{\cdot}3\%}{100} = 31{\cdot}5 \text{ drams} = 1 \text{ oz. } 15\tfrac{1}{2} \text{ drams.}$$

Example 3.—Find the direct loss per cent. and per lb. in a regain of 12 per cent. as in flax.

Let 100 = dry weight,

Then 100 + 12 per cent. = 112 original weight necessary to produce 100 lbs. dry weight.

(1) Direct loss% $= \frac{\text{Loss on orig. wght.} \times 100}{\text{Original weight}} = \frac{12 \times 100}{112} = 10{\cdot}71\%$

(2) Direct loss per lb. $= \frac{\text{Original weight} \times \text{loss}\%}{100}$

$= \frac{256 \times 10{\cdot}71}{100} = 27{\cdot}5$ drams $= 1$ oz. $11\frac{1}{2}$ drams.

Example 4.—If 9 hanks taken from a bundle of yarn weigh $\frac{3}{4}$ lb., and they lose 30 drams of moisture during testing, what is the direct loss per cent.; the absolute dry weight per cent., and how does it compare with the standard regain of moisture for worsted yarn.

(1) Original weight $= \frac{3}{4}$ lb. $= \frac{256 \times 3}{4} = 192$ drams.

(2) Dry weight $= 192 - 30 = 162$ drams.

(a) Then direct loss $\% = \frac{30 \times 100}{192} = 15{\cdot}625$

(b) The absolute dry weight $\% = 100 - 15{\cdot}625 = 84{\cdot}375$

(c) Regain allowed on 84·375 at $18\frac{1}{4}\%$

$= \frac{84{\cdot}375 \times 18\frac{1}{4}}{100} = 15{\cdot}4$

Then absolute dry weight per cent. plus the regain officially allowed equals

84·375 + 15·4 = 99·775 units of wght. out of every 100 of the bulk.

Or, 100 − 99·775 = 0·225 excess of moisture in every 99·775 lbs. which is so small that it can be practically ignored.

Example 5.—420 ends are taken from a warp 70 yards long. The counts of warp are ticketed 2/60s cotton. When absolute dry weight has been obtained they show a loss of 23 drams. If the original weight corresponds with the calculation weight and the sample is typical of the bulk, does the material accord with the standard allowance of moisture of $8\frac{1}{2}\%$?

(1) Calculation and original weights =

By formula XXI.,

$$\frac{420 \text{ ends} \times 70 \text{ yards}}{30 \times 840} = \frac{7}{6} \text{ lb. and } \frac{7}{6} \times \frac{256}{1} = 298\tfrac{2}{3} \text{ drs.}$$

Then the dry weight $\therefore = 298\frac{2}{3} - 23$ drs. $= 275\frac{2}{3}$ drs.

And by formula XXVI.,

$$\text{Direct loss } \% = \frac{23 \times 100}{298\frac{2}{3}} = 7{\cdot}7\%$$

Absolute dry weight per cent. $= 100 - 7{\cdot}7 = 92{\cdot}3$

The regain allowed on 92·3 at $8\frac{1}{2}\% = \frac{92{\cdot}3 \times 8\frac{1}{2}}{100} = 7{\cdot}84.$

Then absolute dry weight per cent. plus the regain officially allowed equals

92·3 + 7·84 = 100·14 units of weight which 100 actual units of the above material ought to weigh with the standard allowance of moisture for cotton.

The warp is therefore deficient in moisture to the extent of 0·14 on 100·14 units of weight which is about $\frac{7}{50}$ per cent.

The deficiency of moisture is slight, yet at the same time it is to the seller's advantage to get the warps up to the standard weight, and so obtain the full benefit in price for his material.

In conditioning houses tests are made, in addition to that of moisture, for percentages of all foreign matter such as grease, oil, soap, gum and size, and also for twist, strength, elasticity, and counts of yarn.

Example 6.—If 6 lbs. of greasy wool are thoroughly scoured and cleansed of all sand, dirt, lime, etc., and absolutely dried, the total loss of weight is 60 per cent.; find the net commercial weight, also the net loss per cent. of foreign matter.

(1) Then 6 lbs. of greasy wool less 60 per cent.

$$= 6 - \left(\frac{6 \times 60}{100}\right) = 6 - 3{\cdot}6 = 2{\cdot}4 \text{ lbs. absolutely dry wool.}$$

(2) The commercial weight of 2·4 lbs. of absolutely dry wool

$$= \frac{(\text{Dry weight}) \times (\text{Standard regain \%} + 100)}{100}$$

$$= \frac{2{\cdot}4 \times 116}{100} = 2{\cdot}784 \text{ lbs.} \quad \text{Answer.}$$

(3) The net loss of foreign matter on 6 lbs. greasy weight $= 6 - 2{\cdot}784 = 3{\cdot}216$ lbs.

Then, since 3·216 lbs. represent the net loss on 6 lbs., the loss per cent. equals

$$\text{As } 6 : 100 :: 3{\cdot}216 : x$$

$$= \frac{3{\cdot}216 \times 100}{6} = 53\tfrac{3}{5}\%. \quad \text{Answer.}$$

When testing hanks of yarn for length, they are very carefully measured by winding the thread on a reel, the circumference of which is exactly 1 yard. Revolving around the axis of the reel is a single toothed worm which controls a small train of wheels,

which, in turn, set in motion the needle of an indicator. When the needle is opposite any number inscribed on the disc or clock face, that number exactly corresponds with the revolutions made by the wheel. The tension is very accurately regulated to coincide with the tension put upon the yarn during the reeling process, *i.e.*, in the department where the yarn is made into hanks.

Example 7.—One hank of 20s worsted is tested for length and counts. It measures exactly 548 yards and weighs 12·8 drams. What is the exact count ?

Then 1 lb. = 256 drs., and $\frac{256}{12{\cdot}8} = 20$ hanks per lb.

But these hanks are 8 yards short in length, therefore the weight must be made up by the increased thickness of the yarn.

Then 20 hanks, each 548 yards, represent the total length.

Then by formula I.,

$$\frac{548 \times 20}{560} = 19\tfrac{1}{2} \text{ cts.} \quad \text{Answer.}$$

EXERCISES.

1. If the standard allowance of regain be $12\frac{1}{2}\%$, what is the direct loss per cent. and per lb. ?

Ans., 11·11 ; $28\frac{1}{3}$.

2. If the absolute dry weight of a textile material is 87·7, what amount of regain *per cent.* is necessary to bring the material up to 100.

Ans., 14.

3. If 2 lbs. of yarn lose 79 drams of moisture in testing, what is the direct loss per cent. and the amount of regain per cent necessary to produce the original weight ?

Ans., 15·43 ; 18·24.

4. The regain for wool is 16 per cent. What weight in drams should 1 lb. of wool lose in testing, and what is the percentage of absolutely dry material ?

Ans., $35\frac{1}{4}$; 86·23.

5. 240 ends of 2/40s worsted warp are taken from a warp 140 yards long. Their actual weight coincides with the calculation weight. When absolute dry weight has been obtained they reveal a loss of $7\frac{1}{2}$ ozs. What is the absolute dry weight per cent. ?

Ans., 84·38.

6. A quantity of greasy wool weighing 5 lbs. loses in sand, dirt, grease, etc., 2·5 lbs. When the standard allowance of moisture is added to the absolute dry weight, what is the commercial weight ?

Ans., 2·7 lbs.

7. 1 Hank of worsted weighs $\frac{1}{24}$ of a lb. It is supposed to be 24s, but it only reels 540 yards. What are the actual counts ?

Ans., 23

8. A pack (240 lbs.) of unscoured wool is sent to be tested. 7 lbs. are made up from 3 separate parts of the bale, being typical of the bulk. This sample loses 4 lbs. in weight when all the grease, sand, dirt, and moisture are extracted. If the standard allowance for greasy wools be now added, what is the net commercial weight of wool ?

Ans., 119·3.

9. If 1 lb. of cotton yarn loses $23\frac{1}{4}$ drams in the testing oven when absolute dry weight is obtained, what is the direct loss per cent., the absolute dry weight, the amount of regain necessary to produce the original weight, and the excess or deficiency per cent. of moisture as compared with the standard allowance for cotton.

Ans., 9·08 ; 90·92 ; 10 ; 1·38 excess.

10 What is the loss per lb., and the direct loss per cent. when the standard allowance for jute is $13\frac{3}{4}\%$?

Ans., 31 drams ; 12·09.

CHAPTER XVI.

Calculations Involved in the Analysis and Reproduction of Woven Fabrics.

The ANALYSIS OF A CLOTH consists in determining :—

The nature of the material of which the fabric is composed
The weight per yard.
The counts of warp and weft.
The ends and picks per inch or other unit.
The design.
The quantities of each colour, if more than one shade be used.
The kind of finish the cloth received.
Other treatment which the yarn or fabric may have received.

In this chapter it is proposed to consider and exemplify the various calculations arising from the study and practice of the analysis and reproduction of woven textures of similar weight and fineness to any sample supplied.

The principles and problems involved will be best demonstrated by a careful consideration of the following typical examples worked out in detail.

A. To Find the Weight per Yard.

Weigh one square inch or as many square inches of sample supplied as is convenient. In order to attain very great accuracy it is found desirable in practice to use a grain balance. Then by simple proportion the weight per yard for any required width of cloth may readily be obtained in grains, ounces, or otherwise —ounces by preference.

Example 1.—A piece of worsted coating, 2 inches square, weighs 20 grains; what would be the weight per yard of a cloth which is to be 56 inches wide when finished, and contain 37 inches per yard?

Then since $2'' \times 2'' = 4$ square inches.

And 1 yard of cloth $37 \times 56 = 2072$ square inches.

Also $\frac{\text{Weight of given cloth in grains}}{\text{No. of square inches in sample weighed}} = \text{Weight of 1 sq. inch in grains.}$

$$= \frac{20}{4} = 5 \text{ grains per square inch.}$$

$\therefore$ Weight per yard in grains = No. of sq. ins. in 1 yd. of cloth $\times$ weight per square in. of given cloth.

$$= 2072 \times 5 \quad = 10{,}360 \text{ grains.}$$

The weight of most woven fabrics is usually expressed in ozs. per yard, and since there are 7000 grains in 1 lb. avoirdupois.

Then weight per yard in ozs. $= \frac{\text{Weight per yard in grains}}{\text{No. of grains in 1 lb.}} \times \text{ozs. in 1 lb.}$

$$= \frac{10360 \times 16}{7000} = 23{\cdot}68 \text{ ozs.}$$

The above detailed solution admits of the following simplification, which I think will be evident without any further explanation.

FORMULA XXIV.

$$\frac{\text{Wt. in grs. of sample} \times \text{No. sq. ins. in 1 yd. cloth} \times \text{ozs. per lb.}}{\text{No. sq. ins. of sample wghd.} \times \text{No. grs. in lb.}} = \text{The weight per yard in ozs.}$$

The foregoing explains the principles which underlie the work to be done, and should be thoroughly understood by each student, but I have formulated a much shorter method for use in practice. It consists in

reducing to one uniform number or *gauge point* all the constant factors.

A *gauge point* is a standard number which is a simple equivalent to all the constant factors in any set of problems, fractions, or equations. In the above example the constant factors are 1 yard, fixed width, ozs. per lb., and grains in 1 lb. avoirdupois.

Then for all cloths 37 inches × 56 inches, the gauge point

$$= \frac{\text{Inches per yard} \times \text{width in inches} \times \text{ozs. per yard.}}{\text{Grains in 1 lb. avoirdupois.}}$$

$$= \frac{37 \times 56 \times 16}{7000} = 4{\cdot}736 \text{ or } 4\tfrac{3}{4} \text{ for all practical purposes.}$$

Note.—If 1 square inch of sample actually weighed 1 grain, then 4·736 ozs. or $4\frac{3}{4}$ ozs. would represent its weight per yard for 37″ by 56″ wide. Consequently, if 1 square inch weighed 2, 3, or 4 grains, its weight per yard would be 4·736 × 2; 4·736 × 3; and 4·736 × 4 ozs. per yard respectively.

Then the whole expressed as a formula stands thus:—

Formula XXV.

Gauge point for any given length and width × weight in grains of 1 square inch of cloth = weight per yard in ozs.

and applies to finding the weight per yard of any given cloth of similar length and width as is represented by ' Gauge Point.'

The utility of the formula is at once apparent when applied to the solution of example 1, where 4 square inches weighed 20 grains.

Then 1 square inch weighs $\frac{20}{4} = 5$ grains, and by formula XXV., 4·736 × 5 = 23·68 ozs. per yard, as previously obtained.

Example 2.—Given a small pattern of cloth 3 × 2 inches which weighs 24 grains, find the weight per yard, 56 inches finished and 37 inches per yard.

Then $\frac{24 \text{ grains}}{6} = 4$ grains, in 1 sq. inch of cloth.

And by formula XXV.

$$4{\cdot}736 \times 4 = 18{\cdot}944 \text{ ounces per yard.}$$

In pattern analysis, it is very often advisable to obtain the weight per yard for 56 inches × 36 inches since it is much easier to obtain the counts of warp and weft from the weights thus acquired.

TABLE IV.

	Width.		Inches per yard.		Gauge point.		
1.	56	×	37	=	4·736	or	$4\frac{3}{4}$
2.	56	×	36	=	4·6	or	$4\frac{3}{5}$
3.	57	×	37	=	4·82	or	$4\frac{4}{5}$
4.	57	×	36	=	4·69	or	$4\frac{7}{10}$
5.	55	×	37	=	4·65	or	$4\frac{13}{20}$
6.	55	×	36	=	4·525	or	$4\frac{1}{2}$
7.	54	×	36	=	4·44	or	$4\frac{4}{9}$
8.	52	×	36	=	4·27	or	$4\frac{7}{25}$
9.	48	×	36	=	3·95	or	$3\frac{19}{20}$
10.	42	×	36	=	3·456	or	$3\frac{3}{7}$
11.	38	×	37	=	3·21	or	$3\frac{1}{5}$
12.	38	×	36	=	3·129	or	$3\frac{1}{8}$
13.	37	×	37	=	3·129	or	$3\frac{1}{8}$
14.	36	×	37	=	3·04	or	3
15.	36	×	36	=	2·96	or	3
16.	29	×	37	=	2·45	or	$2\frac{9}{20}$
17.	29	×	36	=	2·38	or	$2\frac{2}{5}$
18.	28	×	37	=	2·368	or	$2\frac{2}{5}$
19.	28	×	36	=	2·3	or	$2\frac{3}{10}$
20.	24	×	36	=	1·97	or	2

Then the gauge point or formula for 56 inches × 36 inches

$$= \frac{56 \times 36 \times 16}{7000} = 4{\cdot}6.$$

By a similar process the standard number for any other customary width and length may be procured. The gauge point for a few of the most typical widths is supplied at Table IV.

As a result of experiment and contemplation upon this subject I have been able to deduce the following short method which should prove of much practical advantage.

The weight in grains of a small sample of cloth whose area is equivalent to any of the foregoing gauge points in square inches is equal to the weight in ozs. per yard for the standard width which the gauge point represents *e.g.* (1) Consider item No. 7, where the gauge point is 4·44 square inches. Then if 4·44 square inches weigh 22 grains, the weight per yard (36″) 54 inches wide = 22 ounces.

Proof :—If 4·44 square inches of cloth weigh 22 grains the weight of 1 sq. in. $= \frac{22}{4{\cdot}44} = 4{\cdot}95$ grains and by previous demonstration (Formula XXV.) the weight in grains multiplied by the gauge point equals the ounces per yard $= 4{\cdot}95 \times 4{\cdot}44 = 22$ ozs.

(2) If 3 square inches, the gauge points for items 14 and 15 weigh 9 grains, the weight per square yard of fabric would be 9 ozs.

Then all the manufacturer or analyst has to do is to get a ' die ' made to stamp out an area of cloth in

accordance with the gauge point for the width of fabric which he is accustomed to make or has usually to quote for.

B. Determination of the Warp and Weft.

Before ascertaining the counts of warp and weft it will be as well to note the following guiding factors which assist in distinguishing warp from weft in the cloth.

1. If the sample of cloth submitted for analysis shows the reed marks or contains a selvedge, the warp direction is at once obvious.
2. If one set of threads be two-fold and the other single, the two-fold usually represents the warp.
3. The direction of the twist in the warp threads is usually from right to left.
4. If one set of threads be harder twisted than the other, the hard twisted threads represent the warp.
5. If the cloth has a dressed face finish, the direction of the nap indicates the warp.
6. When the yarns are of unequal thicknesses, the finer and better quality *usually* represents the warp.
7. If one set of threads be cotton and the other woollen, worsted, or linen, the cotton threads usually indicate the warp.
8. If one set of threads has been sized and the other has not, the former represents the warp.

The counts of warp and weft may be obtained in several ways, *e.g.*

I. By Comparison. This method, though somewhat crude, is yet simple and ready, and therefore frequently resorted to in practice for low and medium counts of yarns, which, when compared in a practised hand and with an experienced eye yields fairly accurate

results, for which reason it is given a place in this work.

It consists in extracting a few threads from the cloth, which are crossed and folded over a few threads of some known count, the two ends of each respective group of threads being taken and held between the fingers—the group of the unknown in one hand, and the known in the other. The two groups are then simultaneously twisted so as to compare their relative counts.

By the simple act of twisting, we necessarily make a comparison of the areas and solidities of the threads, and since areas and solidities of threads are represented by the equivalent term "counts of yarns," it follows that when the number of threads of some known count is of equal thickness to some other number of known or unknown counts, these numbers bear a simple and direct proportion to each other. During comparison, threads are added or taken from one or other of the sets and again twisted as above and compared until the two sets appear to make a similar thickness of thread.

Example 1.—6 threads of 2/30s worsted are found by twisting and comparison to equal 8 threads of some unknown count, what are the counts of the latter?

Then since the counts of yarn vary in the same ratio as the number of threads of yarn which are compared, they may be found by proportion, thus :—

As $6 : 8 :: 15 : x = 20$s counts or 2/40s worsted.

i.e., 8 threads twisted together of 2/40s are equal in

thickness to 6 threads of 2/30s worsted twisted together.

II. By Weighing Small Quantities of Warp or Weft.

Obtain as many inches of yarn (warp or weft) by taking as many threads from the cloth as is possible and weigh exactly, say to the 100th part of a grain. Then since the number of yards of *worsted* which weighs 12·5 grains equals the counts, and supposing we have obtained 9 threads each 4 inches long (1 yard) and these are found to weigh 1 grain, the counts of this yarn would be 12·5s, because it would require $12\frac{1}{2}$ yards to weigh 12·5 grains.

Example 2.—If 12 threads each 3 inches long are found to weigh ·87 grains, find the counts in worsted.

∴ As ·87 : 12·5 :: 1 : $14\frac{3}{8}\frac{2}{7}$s counts.

Example 3.—If 72 inches of cotton yarn weigh ·4 grains, what are the counts?

Then, since the number of yards of *cotton* which weighs $8\frac{1}{3}$ grains equals the counts,

∴ As ·4 : $8\frac{1}{3}$ :: 2 : $41\frac{2}{3}$s counts.

When adopting this method it is necessary to consider the loss in weight during scouring and finishing, together with the amount of take-up in length of warp and weft in the process of manufacture. In some instances, particularly in fancy worsteds which are woven on the square, the loss of weight in scouring and finishing is neutralised by the shrinkage in length of warp and weft as far as ascertaining the counts of yarn is concerned; consequently, the results

obtained by the above method would coincide with the actual counts of the material used in the construction of the cloth. No law can, however, be laid down which admits of general application.

III. By Weighing a Small Sample of Cloth.

Weigh a small piece of cloth, as a rule 1 square inch, then count the threads and picks per inch, and if they are equal in thickness add them together to find the total length of yarn weighed. After allowing for loss in scouring and finishing together with shrinkage in length and width, find by simple proportion the number of yards which weighs 12·5 grains. This number will represent the required counts in worsted.

Example 4.—Assume that 1 square inch of worsted material weighs 3 grains and contains 60 ends and picks per inch, the warp and weft being of equal thickness, the loss in weight by scouring and finishing is neutralised by the contraction in length of warp and weft. Find the counts of warp and weft.

Then total length of yarn weighed = 60 in. of warp.
and 60 in. of weft.
= 120 in. of yarn.

$$\therefore \text{ As } 3 : 12{\cdot}5 :: \tfrac{120}{36} \text{ yds.} : x$$

$$= \frac{120 \times 12{\cdot}5}{36 \times 3} = 13\tfrac{8}{9} \text{ counts worsted,}$$

or approximately 14s = 2/28s worsted.

Example 5.—A small sample of dyed single worsted cloth weighs $2\frac{1}{2}$ grains per square inch. It contains 96 ends and 76 picks per inch, the relative weight of warp and weft is as 2 to 3 respectively. The loss in

weight after dyeing, scouring, and finishing, is estimated at 5 per cent. The shrinkage in the length of the warp is $\frac{1}{5}$, and of weft $\frac{1}{20}$; find the counts of warp and weft used in the construction of the fabric.

1. The weight of 1 square inch, plus loss in scouring and finishing $= \frac{5}{2} \times \frac{100}{95} = \frac{50}{19}$ grains.

(2) And the weight of warp $= \frac{50}{19}$ grs. $\times \frac{2}{5}$ pts. $= \frac{20}{19}$ grs.

(3) Also the weight of weft $= \frac{50}{19}$ grs. $\times \frac{3}{5}$ pts. $= \frac{30}{19}$ grs.

(4) The length of warp before shrinkage = 96 threads per inch $\times$ 5 parts originally $\div$ 4 parts finished.

$$= \frac{96 \times 5}{4} = 120 \text{ inches.}$$

$\therefore$ 120 inches of warp weigh $\frac{20}{19}$ grs.

(5) The length of weft before shrinkage $= \frac{76 \times 20}{19} = 80''$

$\therefore$ 80 inches of weft weigh $\frac{30}{19}$ grs.

(6) Then cts. of w'p $= \frac{120}{36} \times \frac{25}{2} \times \frac{19}{20} = 39\frac{7}{12}$ or 2/80s wtd.

(7) And cts. of weft $= \frac{80}{36} \times \frac{25}{2} \times \frac{19}{30} = 17\frac{2}{3}$ or 2/36s wtd.

Example 6.—A cotton fabric, 1 $\times$ 3 inches, weighs 6 grains. It contains 80 threads and 72 picks per inch, the relative weight of warp and weft in the same area of cloth is as 3 to 2 respectively. The take-up in length and width is 5 per cent. The weight of size which it contains is estimated at 120 per cent. Find the counts of warp and weft.

(1) Wght. of 1 sq. in. of cloth including size $= \frac{6 \text{ grains}}{1'' \times 3''} = 2$ grs.

(2) ,, ,, ,, ,, without ,, $= \frac{2 \times 100}{220} = \frac{10}{11}$ grs.

(3) ,, wp. in 1 sq. in. of cloth unsized $= \frac{10}{11} \times \frac{3 \text{ pts}}{5} = \frac{6}{11}$ grs.

(4) ,, wft. ,, ,, ,, ,, $= \frac{10}{11} \times \frac{2 \text{ pts.}}{5} = \frac{4}{11}$ grs.

(5) Lgth. of wp. before shrinkage, in yds. $= \frac{80'' \times 100}{36 \times 95} = \frac{400}{171}$ yds.

(6) ,, wft. ,, ,, ,, , $= \frac{72 \times 100}{36 \times 95} = \frac{40}{19}$ yds.

(7) Therefore counts of wp. $=$ as $\frac{6}{11}$ grs.: $\frac{25}{3}$ grs. : : $\frac{400}{171}$ yds.: x cts.

$$= \frac{400 \times 25 \times 11}{171 \times 3 \times 6} = 36\text{s cotton.}$$

(8) The counts of weft $=$ as $\frac{4}{11}$ grs.: $\frac{25}{3}$ grs. : : $\frac{40}{19}$ yds.: x cts.

$$= \frac{40 \times 25 \times 11}{19 \times 3 \times 4} = 48\text{s cotton.}$$

IV. Alternative Method to No. III.

The loss in weight due to boiling decreases the weight of the yarn and produces an *apparently* higher count, while the contraction or shrinkage in length increases its relative weight and contributes to make an *apparently* lower count ; consequently if the difference in these two factors be obtained the result can be added to or deducted from the ascertained weight of yarn sample tested and from this the counts of the yarn may be found as already demonstrated.

As a second alternative the counts, for all practical purposes, may be first ascertained for the finished weight or condition in which the material is tested, then to the weight of counts must be added the excess

of loss in scouring, boiling, bleaching, or other treatment, over contraction in length or width. The width of the material in the loom can then be separately determined by the estimated or known shrinkage as set forth in the following pages.

Example 7.—If one square inch of linen fabric weighs 2 grains, the ends and shots per inch finished are 45, assume 8% has been lost in weight by treatment and the contraction is 4% for length and width, find the lea counts assuming warp and weft to be equal.

Then according to reasoning in method IV. The loss % through treatment − contraction % = the equivalent net loss in weight for original length of thread, thus :—

8% loss − 4% contraction = 4% net equivalent loss.

Therefore the original weight for original natural length of spun yarn before treatment

= Weight in grains of sample weighed + net loss %

$$= \frac{2 \times 100}{96} = \frac{25}{12} \text{ grains.}$$

And since the number of yards of lea yarn which weigh $23\frac{1}{3}$ grains equals the counts

$$\therefore \quad \text{As } \frac{25}{12} : \frac{70}{3} :: \frac{45 + 45}{36} : x.$$

Where x = the required lea count

$$= \frac{90}{36} \times \frac{70}{3} \times \frac{12}{25} = 28\text{s linen.}$$

or by the second alternative plan in method IV.

$$\text{As } 2 : \frac{70}{3} :: \frac{45 + 45}{36} : x$$

$= \frac{90}{36} \times \frac{70}{3} \times \frac{1}{2} = \frac{175}{6}$ lea counts of yarns in sample state.

∴ Since the net loss % = 4 as above, the original lea counts would be $\frac{175}{6} \times \frac{96}{100} = 28$.

By the third method, the counts

$$= \frac{1}{2} \times \frac{90}{36} \times \frac{100}{96} \times \frac{92}{100} \times \frac{70}{3} = 27{\cdot}95.$$

Example 8.—A sample of a plain boiled linen fabric contains 85 threads per inch which weigh 0·7 grains and 96 picks per inch with an aggregate weight of 0·6 grs. If the contraction in width is 6% and that of the length 4% ascertain the counts of the spun thread after allowing 10% for boiling.

Then by method IV.

(1) Warp 10% − 4% = 6% net loss in weight.
(2) Weft 10% − 6% = 4% ,, ,,

∴ Counts of linen warp $= \frac{85}{36} \times \frac{70}{3} \times \frac{94}{0{\cdot}7 \times 100} = 74$s.

And counts of linen weft $= \frac{96}{36} \times \frac{70}{3} \times \frac{96}{0{\cdot}6 \times 100} = 99{\cdot}5$s.

The cloth would be made with 75s lea warp and 100s weft.

Example 9.—A double damask in the finished state contains 90 ends and 140 picks per inch respectively. One square inch weighs 2·1 grains. Assuming that it has lost 15% in bleaching, contracted 10% from reed to finished state and 4% in length and that the relative weight of warp to weft in one square inch is as 1 to 2, find the counts of warp and weft.

Then finished weight of warp $= \frac{2 \cdot 1}{3} = 0 \cdot 7$ grs.

And ,, ,, weft $= \frac{2 \cdot 1}{3} \times 2 = 1 \cdot 4$ grs.

Also net loss in weight of warp $= 15\% - 4\% = 11\%$

And ,, ,, ,, weft $= 15\% - 10\% = 5\%$

$\therefore$ Counts of warp $= \frac{90}{36} \times \frac{70}{3} \times \frac{89}{0 \cdot 7 \times 100} = 74\frac{1}{6}$s

And ,, ,, weft $= \frac{140}{36} \times \frac{70}{3} \times \frac{95}{1 \cdot 4 \times 100} = 61 \cdot 5$s

The actual warp and weft would be 75s and 60s lea respectively since the lea counts, up to 100 generally run in 5s.

C. Determination of Set and Picks in Loom.

First ascertain the number of ends and picks in one inch of the finished cloth, then the product of the finished width in inches and the number of ends per inch must equal the total number of ends in the whole warp. Now, if this total be divided by the number of inches of warp in the reed, the result will consequently equal the ends per inch of the warp in the loom.

The width of the warp in the reed will depend upon the class of goods to be made, the required width of the finished piece and the structure of the design.

In ordinary worsted textures the shrinkage of the cloth from the loom to the finished state, varies from 8% to 12% ; in milled fabrics the shrinkage is often from 25% to 30%, whilst in cotton materials the take-up in length of warp and width of piece is often less than 5% from the loom state.

In linen cloths the contraction in width is difficult to express in terms per cent. which admit of application to all widths since the relative shrinkage for narrow fabrics is greater than for wider textures, *e.g.* A warp 40″in the reed yields 38″ loom state and 36″ finished ; a similar texture 80″ reed produces 77″ loom state and 74 to 75″ finished. Also if the fabric when bleached is shrunk in width from the grey condition it generally pulls out in length somewhat through the process. For purposes of calculation the shrinkage may be generally reckoned as varying from 5 to 10% according to width and special treatment.

The actual varying amount of contraction from reed width to finished state, and vice versa, for a variety of standard widths of linen cambric is shown in Table V. Each cloth is made from 100s warp and 120s weft and woven with 90 ends and 108 picks per inch.

TABLE V.

Cloth width	Reed width	Cloth width	Reed width	Cloth width	Reed width
ins.	ins.	ins.	ins.	ins	ins.
24	24 +5·86%	$37\frac{1}{2}$	$37\frac{1}{2}$+5·32%	$48\frac{1}{16}$	$48\frac{1}{16}$+5·04%
26	26 +5·74%	$41\frac{1}{2}$	$41\frac{1}{2}$+5·26%	$49\frac{1}{16}$	$49\frac{1}{16}$+5·0 %
28	28 +5·68%	$43\frac{7}{8}$	$43\frac{7}{8}$+5·20%	$50\frac{1}{8}$	$50\frac{1}{8}$ +4·96%
30	30 +5·62%	45	45 +5·14%	$51\frac{1}{8}$	$51\frac{1}{8}$ +4·94%
$32\frac{3}{8}$	$32\frac{3}{8}$+5·56%	46	46 +5·12%	$53\frac{1}{8}$	$53\frac{1}{8}$ +4·86%
$36\frac{1}{2}$	$36\frac{1}{2}$+5·44%	47	47 +5·08%	$54\frac{1}{8}$	$54\frac{1}{8}$ +4·82%

In *questions* for *exercises* it is necessary to assume the foregoing or other amounts of shrinkage, and in *practice* to treat each cloth which requires reproduction

upon its separate merits, but the principles of solution for both theory and practice are coincident.

It is also important to remember the following observations, which, I presume, will be readily understood :–

1. The total length of grey warp in yards required to produce 1 yard of finished cloth equals

Ends per inch finished × finished width × grey length of warp in yards required to produce 1 yard of finished cloth.

2. The total length of grey weft in yards required to produce 1 yard of finished cloth equals

Picks per inch finished × width of warp in reed.

or $$\frac{\text{Picks per inch finished} \times \text{finished width} \times 100}{100 - \text{shrinkage of width per cent.}}$$

If shrinkage is expressed as a fraction, then substitute the fractional equivalent for percentage.

Example 1.—Assume a finished fabric, 56″ wide, contains 90 ends and picks per inch. If the contraction in length and width is estimated at 10%, find the grey length in yards of warp and weft to produce one yard of the above finished cloth.

(1) Then No. of yds of wp. in 1 yd. of finished cloth $= 90 \times 56$

Plus 10% for contraction $= \frac{90 \times 56 \times 100}{90} = 5600$ yds. grey.

(2) And the No. of yds. of wft. in 1 yd. of finished cloth $= 90 \times 56$

Plus 10% for contraction $= \frac{90 \times 56 \times 100}{90} = 5600$ yds. grey.

Example 2.—A sample of cloth is found to contain 80 picks and ends per inch. If the shrinkage be estimated at 10%, find the width of the warp in the reed and the number of ends and picks with which it must be woven (assume 56 inches finished).

(a) Total No. of ends in the warp $= 80 \times 56 = 4480$.

And 80 ends finished $= \frac{80 \times 90}{100} = 72$ ends grey

(b) $\frac{4480}{72} = 62\frac{2}{9}$ inches in reed.

Example 3.—A small sample of finished cloth contains 64 ends and picks per inch. If shrinkage be estimated at 9%, find the reed width and the number of ends and picks with which it should be woven. (55 inches finished.)

(a) Total No. of ends in warp $= 64 \times 55 = 3520$.

And 64 ends finished $= \frac{64 \times 91}{100} = 58{\cdot}24$ ends per in. grey.

(b) $\frac{3520}{58{\cdot}24} = 60{\cdot}4$ inches in reed.

Example 4.—A finished fancy worsted coating weighs 13 ozs. per yard (57 inches × 37 inches); it contains 81 ends and 71 picks per inch finished; it loses 10 per cent. weight in scouring and finishing; an average of 70 yards of warp produces 63 yards of cloth out of loom (36 inches), and $55\frac{1}{2}$ yards when finished (37 inches); the width in reed required to produce 57 inches finished is 64 inches. If the warp and weft in 1 square inch or other convenient area are of equal weight, find the counts of warp and weft, and ends and picks per inch required to produce this texture.

(1) Total weight of cloth finished $= \frac{55\frac{1}{2} \times 13}{16} = 45$ lbs.

(2) ,, ,, out of loom $= \frac{45 \times 100}{90} = 50$ lbs.

(3) The weight of warp and weft each equal 25 lbs.

(4) The number of ends per inch in loom

$$= \frac{\text{Ends per inch finished} \times \text{finished width}}{\text{Width of cloth in loom}} = \frac{81 \times 57}{64} = 72$$

(5) The number of picks per inch when it leaves the loom

$$= \frac{\text{Picks per inch finished} \times \text{finished length}}{\text{Length of cloth when it leaves the loom.}}$$

$55\frac{1}{2}$ yds., 37″ finished $= \frac{55\frac{1}{2} \times 37''}{36''} = 57$ yds. 36″ finished.

$$\therefore \quad \frac{71 \times 57}{63} = 64 \text{ picks per inch in loom.}$$

(6) Counts of warp—by formula I.

$$= \frac{72 \times 64 \times 70}{25 \times 560} = 23\text{s counts}$$

(7) Counts of weft—by formula I.

$$= \frac{64 \times 64 \times 63}{25 \times 560} = 18\tfrac{1}{2}\text{s count worsted.}$$

Example 5.—A fancy woollen fabric weighs $3\frac{1}{2}$ grains per square inch. It contains 40 ends and 36 picks per inch finished. The weight of warp and weft in the same area is equal. Allow for loss in scouring and finishing 15% ; for shrinkage from warp length to grey length $\frac{1}{10}$, from grey length to finished length $\frac{1}{10}$, and for shrinkage in width $\frac{1}{7}$. Find weight per yard finished (56 × 37 inches), ends and picks per inch in loom, and counts of warp and weft.

(1) Wght. per yd. (by for. XXV) $56 \times 37'' = 4{\cdot}736 \times 3\frac{1}{2} = 16\frac{3}{5}$ ozs.

(2) ,, ,, ,, $56 \times 36'' = 4{\cdot}6 \times 3\frac{1}{2} = 16\frac{1}{10}$ ozs.

The latter is the necessary factor for finding the counts.

(3) Weight per yard plus loss in scouring and finishing $= \frac{16{\cdot}1 \times 100 \text{ parts}}{85 \text{ parts}} = 19$ ozs. = The original weight of warp and weft required to produce 1 yd. of cloth finished $56 \times 36''$

(4) Weight of warp and weft is equal,

$\therefore \frac{19}{2} = 9\frac{1}{2}$ozs. = original wght. of warp req'd to produce 1 yd. cloth

Also $9\frac{1}{2}$ozs. = ,, ,, weft ,, ,, ,, ,

(5) The ends per inch in loom =

$$\frac{40 \text{ ends finished} \times 6 \text{ parts}}{7 \quad ,,} = 34\tfrac{2}{7} \text{ per inch.}$$

(6) The picks per inch in loom =

$$\frac{36 \text{ picks finished} \times 9 \text{ parts finished}}{10 \quad ,, \quad ,,} = 32\tfrac{2}{5} \text{ per inch.}$$

(7) The reed width $= \frac{56 \text{ in. finished} \times 7 \text{ parts grey}}{6 \text{ parts finished}} = 65\frac{1}{3}$ ins.

(8) The counts of wrp. (by formula I.) $= \left(\frac{40 \times 56 \times 5 \text{ parts}}{4 \quad ,,}\right) \times \left(\frac{2 \times 16}{19 \times 256}\right) = 18\frac{8}{19}$ Y.S. counts

(9) The counts of wft. (by formula I.) $= \left(\frac{36 \times 56 \times 7 \text{ parts}}{6 \quad ,,}\right) \times \left(\frac{2 \times 16}{19 \times 256}\right) = 15\frac{9}{16}$ Y.S. counts

Example 6.—A trousering cloth 28″ finished including list weighs 5 grains per square inch. The relative weight of the face and back cloth is as 10 to 9 (obtained by detaching a portion of the back cloth from the face cloth). The weight of face warp and weft in 1 square inch of cloth is relatively the same, and the relative weight of the face warp to back weft is as 8 to 9. The cloth contains 60 ends and picks per inch of face, and 30 ends and picks of back finished. Assuming that 33 inches reed width is necessary to produce 28 inches finished, and that 68 yards of warp produce 63 yards grey (36″), and 57 yards (36″) finished, find the weight per yard for 28″ × 37″, also the ends and picks per inch in loom, and the counts of warp and weft of face and back respectively.

(1) The weight per yd. (28″ × 27″), table IV., = 2·368 × 5 = 11·84 ozs.

(2) The weight per yard (28″ × 36″), table IV., = 2·3 × 5 = 11·5 ozs.

(3) Total weight of piece plus loss in scouring and finishing $= \frac{11\frac{1}{2} \times 57 \times 100}{16 \times 90} = 45\frac{1}{2}$ lbs.

(4) Weight of face cloth, $\frac{10}{19}$ parts of total warp $= \frac{45\frac{1}{2} \times 10}{19} = 24$ lbs.

(5) Weight of back cloth, $\frac{9}{19}$ parts of total warp $= \frac{45\frac{1}{2} \times 9}{19} = 21\frac{1}{2}$ lbs.

(6) Weight of face warp $= \frac{1}{2}$ face cloth $= 12$ lbs.

(7) Weight of face weft $= \frac{1}{2}$ face cloth $= 12$ lbs.

(8) Weight of back warp $= \frac{8}{17}$ back cloth.

$= \frac{21\frac{1}{2} \times 8}{17} = 10{\cdot}1$ lbs.

(9) Weight of back weft $= \frac{9}{17}$ back cloth

$= \frac{21\frac{1}{2} \times 9}{17} = 11{\cdot}4$ lbs.

(10) Ends of face warp $= \frac{60 \times 28}{33} = 51$ per inch in loom.

(11) Picks of face weft $= \frac{60 \times 57}{63} = 54\frac{2}{7}$ per inch out of loom.

(12) Ends of back warp $= \frac{30 \times 28}{33} = 25\frac{1}{2}$ per inch in loom.

(13) Picks of back weft $= \frac{30 \times 57}{63} = 27\frac{1}{7}$ per inch out of loom.

(14) Counts of face warp $= \frac{51 \times 33 \times 68}{12 \times 560} = 17$s count or 2/34s

(15) Counts of face weft $= \frac{54\frac{2}{7} \times 33 \times 63}{12 \times 560} = 16{\cdot}8$s counts

(16) Counts of back warp $= \frac{25\frac{1}{2} \times 33 \times 68}{560 \times 10{\cdot}1} = 10{\cdot}1$ or 2/20s worsted

(17) Counts of back weft $= \frac{27\frac{1}{7} \times 33 \times 63}{256 \times 11{\cdot}4} = 19{\cdot}3$s Y.S. woollen

Example 7.—A sample of cotton cloth weighs $3\frac{1}{2}$ ozs. per yard (38″ × 36″). It contains 110% of sizing material, $52\frac{1}{2}$ threads and 42 picks per inch. It is assumed to have contracted 5% in length and width. The relative weight of warp and weft is as 3 is to 2 in the same area of cloth. Find the reed width, the ends and picks per inch in loom, and the twist or counts of warp and weft used in its construction.

(1) Act'al wgt. of 1yd cloth less sizing $= \frac{7}{2}$oz. $\times \frac{100}{(100+110)} = \frac{5}{3}$oz.

(2) ,, ,, warp in 1yd. less sizing $= \frac{5}{3} \times \frac{3}{5}$ parts $=$ 1oz.

(3) ,, ,, weft ,, ,, ,, $= \frac{5}{3} \times \frac{2}{5}$,, $= \frac{2}{3}$oz.

(4) Reed width $= \frac{38'' \times 100}{95} = 40$ inches.

(5) Ends per inch $= \frac{52\frac{1}{2} \times 38''}{40} = 50$ in loom.

(6) Picks per inch $= \frac{42 \times 95}{100} = 40$ in loom.

(7) Counts of warp by formula I. $= \frac{52\frac{1}{2} \times 38 \times 100 \times 16 \text{ ozs.}}{840 \times 95 \times 1} = 40$s cotton.

(8) Counts of weft by formula I. $= \frac{42 \times 40}{840} \times \left(\frac{3 \times 16 \text{ lbs.}}{2 \times 1}\right) = 48$s cotton.

Simple Conversion Equivalents of British and French Weights and Measures

In the buying and selling of woven cloths it frequently occurs that quantities quoted in ozs. per square or lineal yard, require to be expressed in grammes per sq. metre or conversely.

The following deduced simple formulæ or equivalent factors will be found most useful in practice :—

Problem and Deduction of Formulæ.

Example 8.—Find the simplest equivalent numerical factor which may be used for the conversion of :—

(a) grammes per square metre into ozs. per sq. yd.

(b) ozs. per sq. yd. into grammes per sq. metre.

(c) kgrs. per sq. metre into lbs. per sq. yd.

(d) lbs. per sq. yd. into kilogrammes per sq. metre.

Data :—

1 Metre (*1000 millimetres*)	$=39{\cdot}37$ inches
1 yard	$=914$ mm.
1 inch	$=25{\cdot}4$ mm.
1 Kilogramme (*1000 grms.*)	$=2{\cdot}2$ lbs.
1 lb. Av.	$=454$ grammes
1 oz. Av.	$=28{\cdot}4$,,
1 sq. metre $=\frac{39{\cdot}37\times39{\cdot}37}{36\times36}$	$=1{\cdot}2$ sq. yds.
1 sq. yd. $=\frac{36\times36}{39{\cdot}37\times39{\cdot}37}$	$={\cdot}836$ sq. mtr.

Solutions A and B—

Let x = weight in grammes per sq. metre

Then $\frac{x \text{ grammes}}{28{\cdot}4 \text{ gms. in 1 oz.}}$ = ozs. per sq. metre

and $\frac{x}{28{\cdot}4}\times\frac{1}{1{\cdot}2}=\frac{x}{34}$ ozs. per sq. yd.

∴ Formula A—

$$\frac{\text{wght. of 1 sq. mtr. in grammes}}{34}=\text{wght. in ozs. per sq. yd.}$$

Conversely Formula B—

wght. in ozs. per sq. yd. $\times 34=$ wt. in gms. per sq. m.

Solutions C and D—

Let y = weight in kilogrammes per sq. metre

Then = y kgs. per sq. mtr. = $2{\cdot}2y$ lbs. per sq. mtr.

,, ,, = $2{\cdot}2y$ lbs. per 1·2 sq yds.

,, ,, = $\frac{2{\cdot}2y}{1{\cdot}2} = \frac{11y}{6}$ lbs. per sq. yd.

∴ Formula C—

$$\frac{\text{wt. of 1 sq. mtr. in kgs.}}{1} \times \frac{11}{6} = \text{wt. in lbs. per sq. yd.}$$

Conversely Formula D—

$$= \frac{\text{wt. of 1 sq. yd. in lbs.}}{1} \times \frac{6}{11} = \text{wt. in kgs. per sq. mtr.}$$

Example 9.—A tent cloth weighs 2 lbs. per square yard ; find its equivalent in kilogrammes per sq. metre.

Solution by formula A=

$$\text{kgs. per sq. mtr.} = \frac{2 \text{ lbs. per sq. yd.}}{1} \times \frac{6}{11} = 1{\cdot}1$$

Example 10.—A linen cambric handkerchief weighs 2 ozs. per square yard ; find its equivalent in grammes per square metre.

Solution by Formula B—

grammes per sq. metre = 2 ozs. per sq. yd. × 34 = 68.

EXERCISES.

General.

1. A sample of costume cloth 2 inches × 2 inches weighs 7·6 grains. Find the weight per yard for 56 inches wide and 37 inches per yard.

Ans., 9.

2. One square inch of a cloth weighs 1·3 grains ; find the weight in grammes per centiare or square metre and ozs. per square yard.

Ans., 130 ; 3·85.

3. If 10 threads each 5 inches long weigh 2·5 grains, ascertain the flax lea number and cotton counts, no allowance to be made for contraction in weaving or loss in weight due to treatment.

Ans., 13 ; 4·64.

4. 24 threads 4 inches long of an unknown count balances 20 threads 4 inches long of 35s counts. Give counts of the unknown yarn.

Ans., 42.

5. A union cloth 30 inches wide weighs 5 ozs. per lineal yard, set 35/40 per inch, 15 inches of warp equals 20 inches weft in weight, contraction 10% in warp and 5% in width due to weaving, find the counts of warp and weft, in cotton and linen respectively.

Ans., 8·6 ; 29.

Woollen and Worsted.

6. 2 square inches of heavy worsted suiting weigh 10·1 grains. Find the weight per yard for 57 inches × 37 inches, and 29 inches × 37 inches.

Ans., 24·34 ; 12·37.

7. A Scotch tweed sample, 3 inches × 2 inches, weighs 27 grains. Find the weight per yard for 55 inches × 37 inches.

Ans., 20·9.

8. 10 threads, each 5 inches long, extracted from a Scotch tweed, weigh 2·5 grains. What are the counts Galashiels and Hawick, assuming the loss in weight by scouring and finishing neutralises the increased relative weight due to shrinkage in length ?

Ans., $19\frac{4}{9}$; 21.

9. 7 threads of woollen warp, each 3 inches long, weigh ·91 grains. What are the counts Y. S. and Halifax Rural District ?

Ans., 17·5 ; 4·55.

10. One square inch of a woollen fabric weighs 3·7 grains. It contains 42 ends and 38 picks per inch. The piece loses 18 per cent. in scouring and finishing. The weight of warp and weft for the same area of cloth are equal. The take-up

in warp and weft is $\frac{1}{6}$. Find the weight per yard for 55 × 37 inches, and the counts and threads per inch in loom of warp and weft.

Ans., $17\frac{1}{5}$; $16\frac{1}{2}$; 15; 35; $32\frac{2}{3}$.

11. A union dressed face cloth contains 44 ends and 48 picks per inch, finished. 1 square inch weighs 3·6 grains. The relative weight of warp to weft is as 1 to 2. The loss of weight in scouring, cutting, and finishing, is ·25 per cent. of weft and 5 per cent. of warp. 70 yards of warp produce 68 out of loom, and 67 finished. 70-inch reed width is required to produce 54 inches finished. Find the counts of cotton warp and woollen weft, the ends and picks in loom, and the weight per yard for 54 × 36 inches.

Ans., $8\frac{3}{7}$; $14\frac{3}{4}$; 34; $47\frac{1}{3}$; 16.

12. A Scotch tweed weighs 5·6 grains per square inch. The weight of warp to weft is as 3 to 2. There are 76 ends and 56 picks per inch finished. 80 yards of warp produce 70 yards out of loom and 60 yards finished. 75-inch reed gives 55 inches finished. The loss of weight in scouring and finishing is 20 per cent. Find the counts of warp and weft in Gala., and weight per yard for 56 × 37 inches.

Ans., $23\frac{3}{7}$; $26\frac{1}{2}$; $26\frac{1}{2}$.

13. A square inch of fancy worsted cloth weighs 1·9 grains. It contains 50 ends and 44 picks of two-fold warp and weft respectively. The relative weight of warp to weft in the same area of cloth is as 10 to 9. The loss of weight in scouring and finishing is 10 per cent. The take-up in length of warp and weft is $\frac{1}{10}$. Find the counts of yarn.

Ans., 2/35; 2/34.

14. A fancy tweed (double-cloth) contains 88 ends and 95 picks per inch. 1 square inch weighs 5·3 grains. The relative weight of warp to weft for the same area of cloth is as 25 to 28. The loss in scouring and finishing is 12 per cent. The take-up in length of warp and weft is $\frac{1}{7}$. Find the counts of yarn in Galashiels.

Ans., 35; $33\frac{5}{6}$.

15. A Scotch tweed contains 25 ends and 23 picks per inch It is finished 55 inches wide including lists. It shrinks 15 per cent. in length after leaving the loom and 20 per cent. in width. Find the number of ends and picks per inch, and the width of piece in the loom.

Ans., 20 ; $19\frac{1}{2}$; $68\frac{3}{4}$.

16. A single fancy costume worsted cloth weighs 2·4 grains per square inch. It contains 66 ends and 54 picks per inch. The relative weight of warp to weft for the same area of cloth is as 15 to 14 ; the take-up in length of warp and weft is 10 per cent. ; the loss of weight in scouring and finishing is 10 per cent. Find the weight per yard in ounces for 57×37 inches ; the counts of warp and weft and the ends and picks per inch used in weaving.

Ans., 11·57 ozs. ; 18·4 ; $16\frac{1}{8}$; 59·4 ; 48·6.

17. A black worsted coating contains 96 ends and 104 picks per inch. 1 square inch weighs 4·5 grains. 70 yards of warp produce 64 yards (36 inches) grey, and 57 yards (36 inches) finished. The width in the reed required to produce 57 inches is 66 inches. Supply the ends and picks per inch in loom ; counts of warp and weft ; and weight per yard for 57×57 inches. The net gain in weight of the piece after dyeing and finishing is 5 per cent., and the weights of warp and weft are equal for the same area of sample.

Ans., 83 ; $92\frac{5}{8}$; 19 ; $19\frac{1}{2}$; 21·69

18. A heavy double fancy worsted cloth contains 81 ends and 75 picks of warp and weft ; there are 2 ends and picks of face to 1 end and pick of back. The weight of one square inch of cloth is 6 grains. The relative weight of face to back cloth is as 8 to 7, and the weights of face warp and weft, and back warp and weft are equal for the same area of cloth. The face warp loses $\frac{1}{10}$. The face weft and back warp and weft shrink $\frac{1}{9}$. Find the weight per yard for 57 inches $\times$ 36 inches, the counts of warp and weft, and the total ends and picks per inch in loom. The loss of weight in scouring and finishing is 10 per cent.

Ans., 28 ; 11·7 ; 11 ; $6\frac{3}{4}$; $6\frac{1}{3}$; 72 ; $66\frac{2}{3}$.

19. A woollen suiting weighs 6·12 grains per square inch It contains 34 ends and 32 picks per inch finished. The weight of warp and weft for the same area of cloth are equal. The take-up of the warp and weft are each $\frac{1}{6}$, and the loss of weight in scouring and finishing is 15 per cent. Find the counts of warp and weft, ends and picks per inch, and the weight per yard for 55 × 37 inches.

Ans., $8\frac{5}{9}$; $8\frac{1}{10}$; $28\frac{1}{3}$; $26\frac{2}{3}$; $28\frac{1}{2}$.

20. A single cloth with 64 ends and picks per inch is woven in 64-inch reed, with 2/48s worsted warp and 2/36 worsted weft. It is required to increase the weight by adding a woollen back to it. There must be 2 ends and picks of face to 1 end and pick of back. The relative weights of face and back cloth must be as 2 to 3 respectively. Find the counts of warp and weft required for the back cloth.

Ans., $17\frac{1}{2}$; $13\frac{1}{8}$.

21. A double cloth weighs 24 ounces per yard when it leaves the loom. It is woven with 60 ends and picks per inch of face and 30 ends and picks per inch of back. Reed width 64 inches. The weight of face to back cloth is as 3 to 4. The counts of face warp and weft are equal as are also the back warp and weft. The take-up in length and width is $\frac{1}{9}$. Find the sizes of twist for face and back in worsted and woollen respectively.

Ans., 24; $19\frac{11}{16}$.

Cotton and Silk.

22. If it is found by comparison that 8 threads of 2/36 cotton are approximately equal to 10 threads extracted from a small sample of cotton cloth, what are the counts of the latter ?

Ans., 2/45s.

23. A weighted cotton fabric contains 66 ends and 72 picks per inch, finished. The take-up in warp and weft is 4 per cent. 1 square inch weighs 1·96 grains. It contains 75 per cent. of sizing. The weights of warp and weft for the same area of cloth are equal. What are the counts of warp and weft,

the ends and picks per inch in the loom, and the weight per yard (38 inches × 36 inches) ?

Ans., $28\frac{2}{5}$; 31; 63·36; 69·12; $6\frac{1}{8}$.

24. A cotton cloth contains 105 ends and 96 picks per inch. 2″ × 3″ weigh 16·2 grains. The weights of warp and weft in the same area of cloth are equal. The weight of size which the same contains is 90 per cent. The take-up in length of warp and weft is $\frac{1}{15}$. What are the actual counts of warp and weft ?

Ans., $36\frac{1}{2}$; $33\frac{1}{3}$.

25. A small sample (8-end sateen weave) of silk brocade, 3 inches × $2\frac{1}{2}$ inches, weighs 15 grains. It contains 248 ends and 312 picks per inch. The relative weight of warp to weft is as 2 to 3. The weight of dye, size, gum, etc., is equal to one half of the original weight. The take-up in length of warp is 8 per cent., and of weft 3 per cent. The pattern is warped 2 threads black organzine and 1 thread yellow organzine.

Weft or filling is 1 pick blue
1 ,, black
1 ,, light green } Tram silk.

Find the original counts in Denier and Dram Systems, ends and picks per inch in loom, and weight per yard, exclusive of lists (24 inches × 36 inches).

Ans., 45; 56; 2·6; 3·26; 240; 287; 3·94

Linen and Jute, Etc.

26. A square yard of linen weighs 6 ozs., it counts 55 × 60 threads per inch, the weights of warp and weft yarns are equal. Find the lea numbers, allowing 10% for contraction in warp and 5% for contraction in weft.

Ans., 40.

27. A linen web is to average 90 yards long, 36 inches wide, and weigh 39/40 lbs., set 60/60 per inch, assume 10% contraction in length and 5% contraction in width. Find counts of warp and weft.

Ans., 36.

28. Given three cloths which count respectively 27, 63 and 94½ threads per inch, the contraction from the reed width to the present condition is 5%. Find the set of the reed in the 40″ scale.

Ans., 513 ; 1197 ; 1795.

29. A sample of linen of 16 square inches weighs 24·1 grains, set 55/65 per inch. Find the lea number of yarns, assuming warp and weft to be equal, and that contraction in length is 10%, and 5% in width.

Ans., 52·5 ; 60.

30. A square of plain brown linen with 3-inch sides, weighs 20·8 grains. When dissected it is found that total warp equals 112 threads weighing 10·57 grains, and total weft equals 108 threads weighing 10·23 grains. After removing contraction, the warp threads measure 82 m.m., and the weft threads 81 m.m. Find (a) the weight in ozs. per square yard, (b) the set of reed, (c) the picks in loom, (d) the counts of warp, (e) the counts of weft.

Ans., 6·83 ozs. ; 694 ; 36 ; 24·1 ; 21·9.

31. Finds the yarns necessary for a 36 in. plain brown linen 92 yards, 36″ measure, to weigh about 40 lbs., reed 7°° on 40 ins., with 7 shots on the 37 inch glass finished, contraction in width and in length 8% in each case.

Ans., 22·65 av.

32. A 24 in checked union glasscloth contains 48 warp threads and 52 weft threads per inch, and weighs 4 ozs. per yard. The order of warping and wefting is 18 white, 2 blue. The contraction from reed width to finished width is 4 per cent., and from warp to finished cloth 10 per cent. Find the counts and yarns necessary to weave 20 pieces of 72 yards each. All the warp, and the blue weft is cotton ; the weft is grey linen yarn. The cotton yarns lose 7½ per cent. in bleaching, dyeing, etc. Assume linen and cotton yarns to be equivalent counts.

Ans., 11·5 ; 32.

33. If 4 square inches of a 38″ linen cloth, 14/14, weigh 7 grains find the weight of a web of 85 yards, 37″ measure.

Allow for shrinkage 10% in length and 5% in breadth and give the lea number.

Ans., 29·9 lbs. ; 59 ; 59¼ ; say 60/60.

34. A 36 inch grey linen, counts 47 threads per inch of warp and 54 threads per inch of weft ; the fabric weighs 27½ lbs. per 100 yards, 37″ measure ; assuming 110 yards of warp and 38″ reed are required to produce this fabric, what suitable lea number of yarn warp and weft, would be required if the weight of warp and weft in the cloth are equal ?

Ans., 45s warp ; 51·1s weft, use 50s.

35. A jute hessian fabric weighs 10½ ozs. per 37″ yard, 40 inches wide. It counts 12 ends and 14 picks per inch finished. Allow for contraction $\frac{1}{11}$ in width and $\frac{1}{12}$ in length, 2% of which contraction in length has occurred since the fabric left the loom. Find (a) the porter reed 37″ scale and the shots per inch in loom, (b) the lbs. per spindle of warp and weft, assuming the weight of warp and weft to equal each other.

Ans., 10 ; 13¾ ; 8·8 ; 7½.

36. If a piece of linen counting 17 × 19 and measuring 6 inches square, weighs 50 grains, find the weight in lbs. per web of 75 yards, 37″ measure and 38″ cloth ; assuming that the yarns have lost 10% due to boiling, that the weights of warp and weft in the web are equal and that 85 yds. of warp and 40″ reed are necessary to produce the given fabric, find the nearest standard lea counts.

Ans., 20·92 ; 82·8 ; 90·8 say 85/90.

37. A dress linen measuring 3 × 2 inches weighs 15·6 grs. ; it counts 47 ends and 32½ picks per inch ; the width of the fabric is 32 inches ; the net loss of weight in the yarns due to treatment is estimated at 8% ; the contraction in width and length is 4%. Find nearest practical set on 40″ scale and the shots on 37″ glass and the nearest lea count of warp and weft ; the relative weight of warp to weft in the same area of cloth is as 3 to 5. Assume the finished and loom length of web to be equal.

Ans., 9°° ; 6 ; 30 ; 2/25.

38. A sample of bleached huckaback 3 × 2 weighs 23 75 grs. ; the weight of warp to weft in the same area of cloth is as 3 to 7 ; the estimated loss of weight due to bleaching is 15% ; $18\frac{1}{4}''$ finished from 20 inch reed and counting 82 ends and 28 double shots of weft. Find the set on 40 in. scale, the shots on 37″ glass and the lea number warp and weft. Contraction in length to be estimated at 5%. Loom state to finished width 2% contraction.

Ans., 15°° ; 10 or 5 double ; 40 ; 12.

39. Given the three following quantities and sizes of napkins :—(a) 96 dozen 21″ × 21″ ; (b) 65 dozen 24″ × 24″ ; and (c) 34 dozen 27″ × 27″, express the quantity of same in square metres.

Ans., (a) 327 ; (b) 289 ; (c) 192

40. A woven cloth is required to weigh 135 grammes per square metre. Find the equivalent weight in ozs. per sq. yd.

Ans., 4.

41. A heavy tent cloth weighs $1\frac{1}{2}$ lbs. per square yard ; find its equivalent weight in kilogrammes per square metre.

Ans., $\frac{9}{11}$.

42. Given the finished size of handkerchief as 24″ × 24″, allow $\frac{3}{4}''$ for each hem and $\frac{1}{4}''$ for cutting and turning on each side. Find the number of square yards and metres per dozen handkerchiefs. Also the total number of square yards and metres contained in 100 gross of the above size of handkerchief.

Ans., 6·26, 5·217 ; 7512, 6260.

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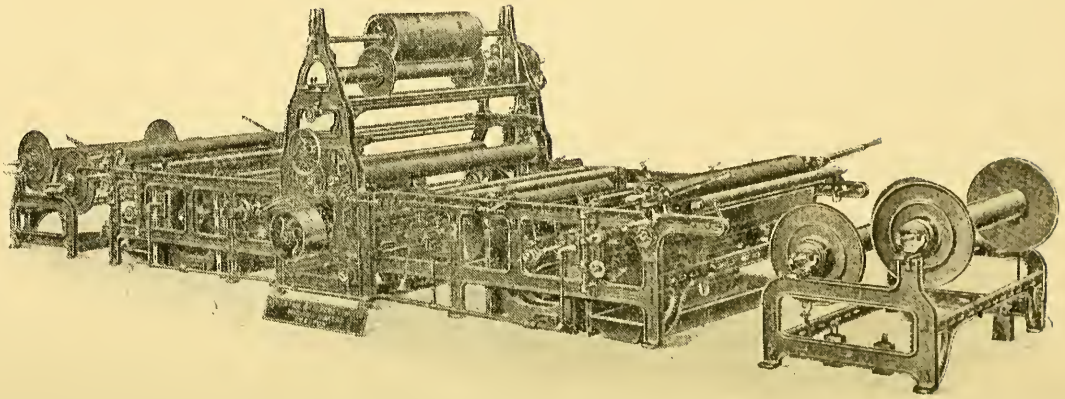

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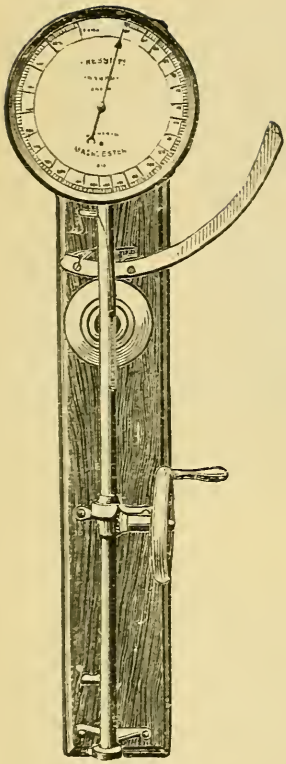

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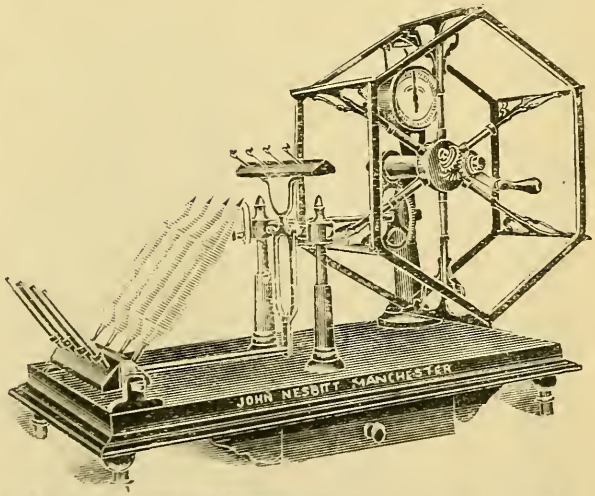

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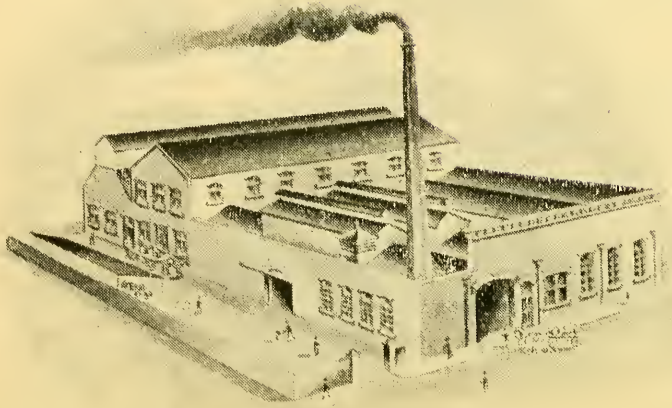

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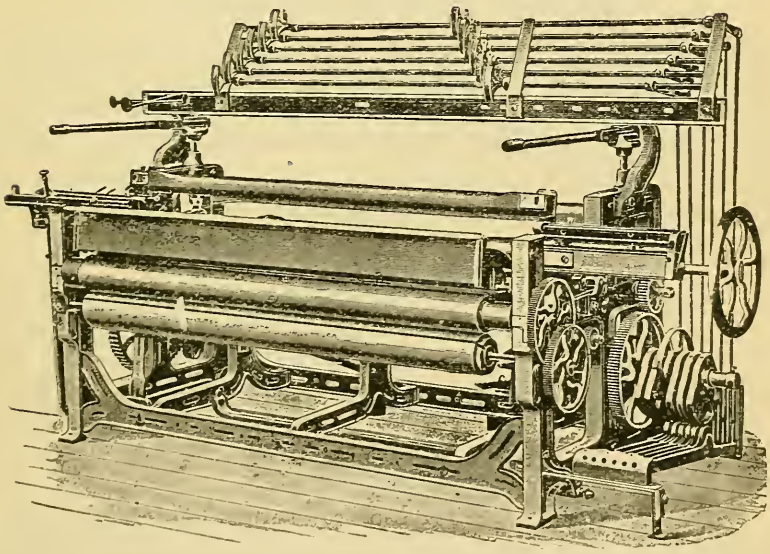

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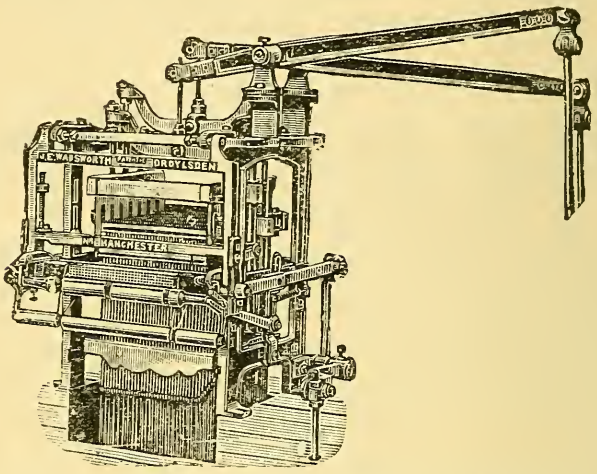

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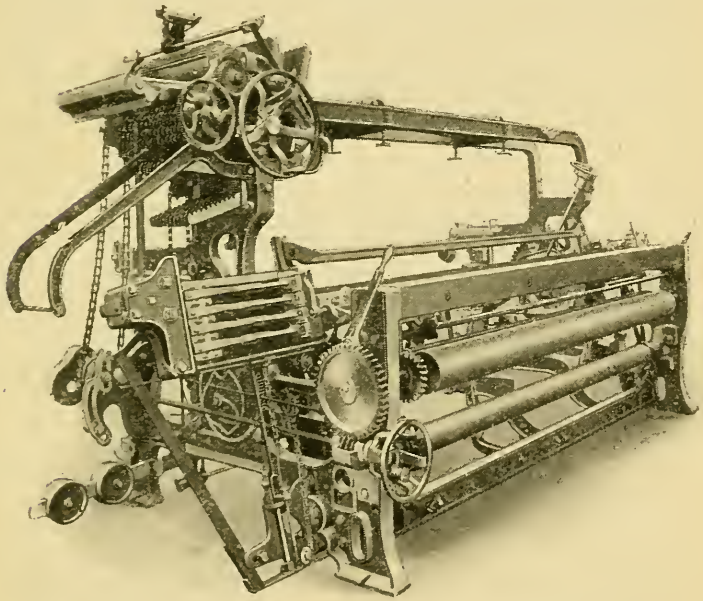

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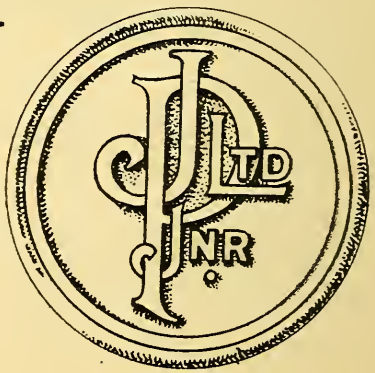

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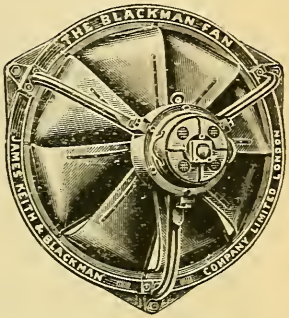

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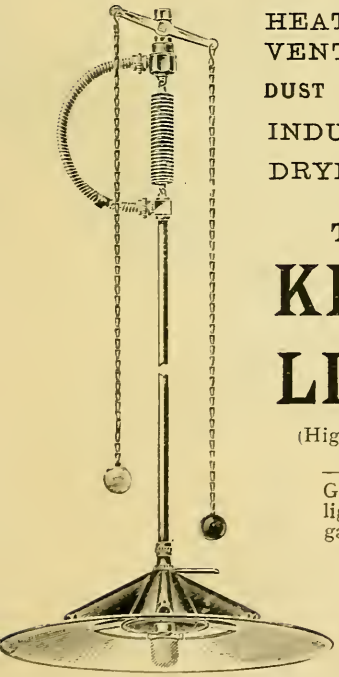

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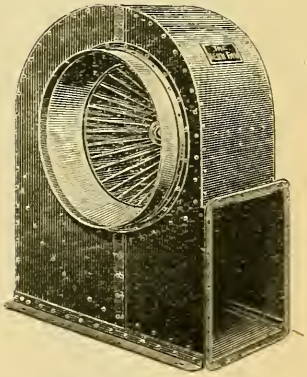

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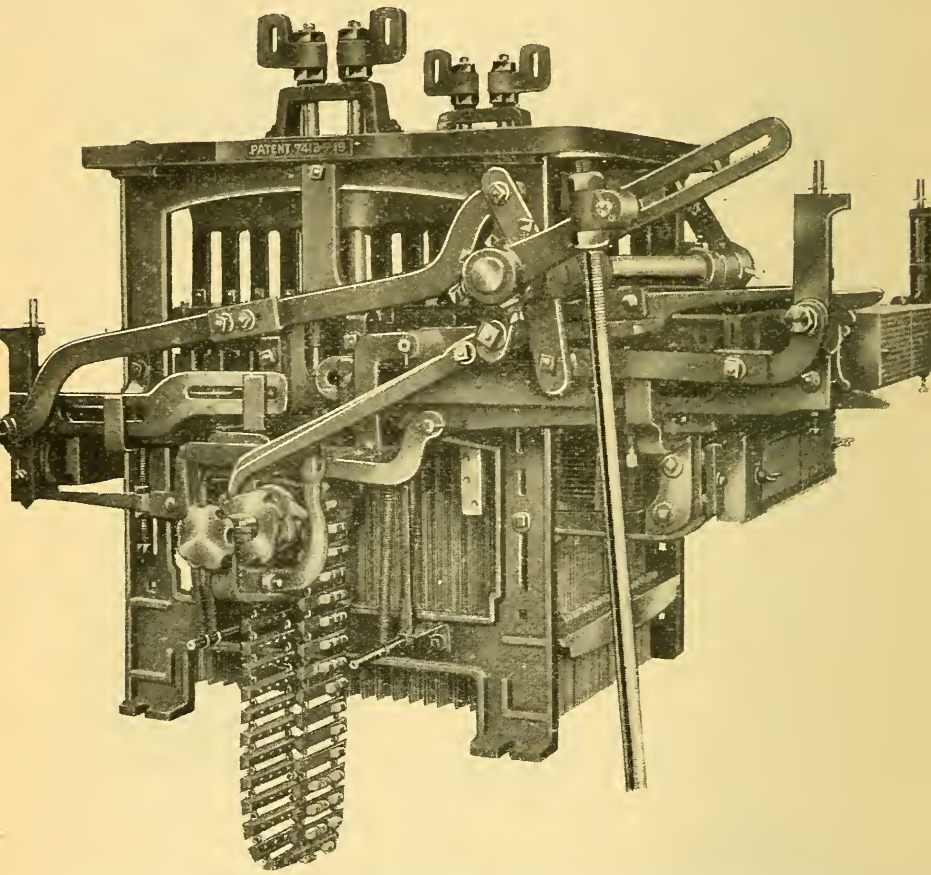

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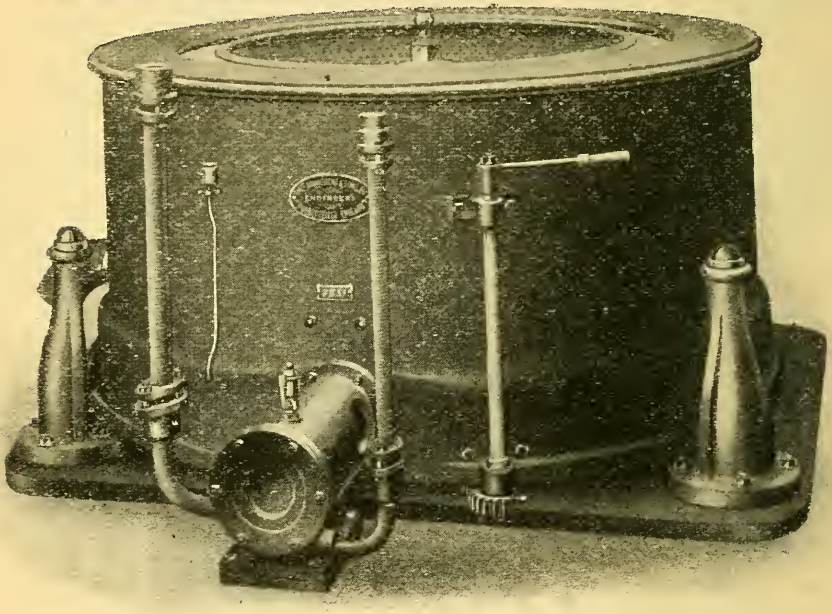

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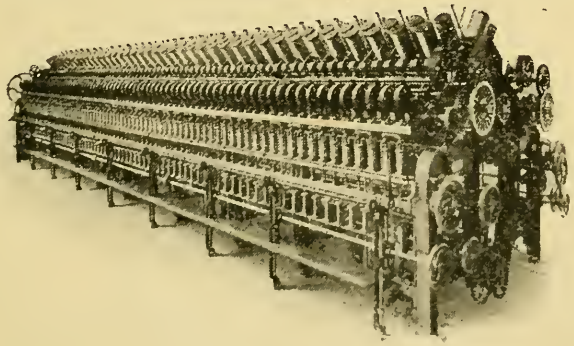

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